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ABSTRACT

A study was conducted from March 1976 through June 1980 on the application and feasibility of a computer micro-system as an interactive tutorial instructional tool in a self-contained classroom. Literature on computer assisted instruction (CAI), hardware, and software was examined. Individualized CAI materials for industrial arts and technology electronics were generated. An instructional model and guidelines for its use were developed. Microprocessor system instructional effectiveness and human factors associated with its classroom use were examined. Findings include the following: (1) CAI program generation is possible only if instructors develop instructional units which stand alone yet interrelate with each other: (2) instructors must consider individual student differences and use student feedback extensively: (3) computers purchased for CAI use should be standard, meet certain minimum capacity requirements, and have readily available maintenance services: (4) most students found CAI as good or better than other media in teaching concepts and skills, felt CAI helped them better meet course objectives, and found lessons readable and easily understood: (5) CAI lessons showed a positive correlation to student grades. Findings affirm CAI feasibility. Investigation of microcomputers for simulation purposes or for use by the handicapped are recommended. (A 100-page appendix contains CAI sample "coursewriter," computer programs, evaluation forms, course outlines, a pretest, list of microcomputer suppliers by product/system, and a bibliography.) (MN)

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THE MICROCOMPUTER AS AN INTERACTIVE INSTRUCTION SYSTEM IN THE CLASSROOM

A Four Year Staff Study Completed in the Department
of Industrial Arts and Technology at the
University of Northern Colorado,
Greeley, Colorado From March
1976 Through June 1980

Dr. David L. Jelden, Professor
Department of Industrial Arts
and Technology

Summer Quarter, 1980

CE 026 694

U.S. DEPARTMENT OF HEALTH,
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CHAPTER I

INTRODUCTION

With advancing technology developing new methods, instructional devices and educational techniques, it is essential for educators to know and understand the implications which computers have for the teaching/learning process.

Computers are generally applied in the classroom in one or more of the following ways: (a) as a management tool which keeps records of student progress; (b) as an assignment prescription device which makes suggested assignments based on past progress of previous lessons; (c) as a management tool which monitors the media or devices available for utilization in a multi-media environment; or (d) as a presenter of information which controls progress through a lesson on an interactive basis with the student responding to information provided by the computer.

In publications which deal with educational applications, their uses are broadly described as computer assisted instruction (CAI) or computer managed instruction (CMI). Most CAI interactive facilities are time-share systems operating with rather large computers or with storage systems costing many thousands of dollars. With the advent of the mini and micro computers now available, many questions exist on the restrictions of these systems. Also, there are many human questions which need to be answered regarding CAI on any size operation, including a micro-system.

Purpose of the Study

The main thrust of this study dealt with the application, restriction and feasibility of a micro-system as an interactive, tutorial, instructional tool in a self-contained classroom. More specifically the study attempted to answer the following questions:

1. What was the minimum system requirement for a four-terminal interactive, multi-user (time-share) extended basic system?
2. What was the optimum CPU memory capacity required for a four-terminal multi-user system?
3. What was the number of interactive tutorial lessons which could be stored on a floppy disk with a maximum lesson contact time of 50 minutes?
4. What was the optimum CPU partition size required to operate a multi-user interactive instruction/management system on a micro?
5. What relationships existed in the micro CAI system with its diagram book and the

traditional, costly, self-paced, automatically programmed visual display system?

6. What were the attitudes of students toward an interactive tutorial CAI system as compared to 16mm films, 1/2 inch video tapes and traditional teacher/lecture presentations?
7. What impact does the interactive CAI system have on retention of material, learning time and comprehension?
8. What human physical/psychological limitations exist in using a cathode ray tube (CRT) and a printer terminal as an instructional device?
9. What recommendations can be made for applications of a micro system as an educational adjunct to existing classroom instructions?
10. What limitations exist for a multi-user extended basic program using a micro system for interactive computer assisted instruction in the classroom?

Need for the Study

Sophisticated computer systems have been available for a number of years for instruction purposes. Their utilization in the military and in civilian schools is well documented. Their availability to all school systems, however, has not been realized for one very good reason--cost. The million plus dollar investment by a small school district for an operational system was impractical and financially unjustified based on the anticipated educational return.

Industry's answer to education was the purchase of computer time on a time/share basis with rental of terminals from the contractor on a monthly basis. This operation works well but the rental of terminals and phone lines for access to the computer at some distant location, many times out of state, was still a large expense. Although this kind of operation is much less expensive than owning your own large system, it was still too costly for many school districts.

In time, another solution was proposed. This was the mini system. A mini time/share operation allowed large school districts to buy a much less expensive system, say in the $100,000 range, and for about 10 percent of the cost of a very large system, have the availability of computer instruction. The cost of the terminals with their maintenance contracts and phone modems, communication networks per school, etc., still made CAI a rather expensive operation. In spite of the fact that educational research has shown the positive benefits of computer assisted instruction both from the standpont of time spent in learning and in the retention of the material, it was not economically feasible for all school systems.

More recently, the state of the art has provided the proliferation of micro systems which are much lower in price and thus within the economic possibility of most school districts. The problem, however, is that when large and mini systems were used, some software and instructional packages were provided as a service by the manufacturer. Also, as the size of the system decreased in cost, the sophistication and capabilities of the computer became more limited. It is possible to make a system so small or inexpensive that its educational worth may be suspect. With this limitation in mind, this study was undertaken. Is it possible to justify educationally, a micro computer as a valid, interactive tutorial instructional tool, which almost any school district can afford and which can be operated and programmed by the average classroom teacher for every day use? This study will attempt to answer this question.

Definition of Terms

For the purpose of this study, the following terms are defined as they were used in disucssion and data presentation:

Adjunct Programming.--A programming method in which the instructional program supplements a handbook, study guide, activity packet or some other source of information. The program is intended to instruct the student in the field being studied and is used to expand on the material it supplements. A linear program in an activity packet supplements the textbook which might be used in answering questions in a student's study guide.

Audiovisual Media.--A means of communication using the sense of hearing or sight or both to augment the learning process.

BASIC.--An acronym describing a type of programming language. To initiate the interactive capability, a form of language must be developed to interface the machine to the operator. As a general rule, a simplified language is developed which directs the computer to provide specific, pre-determined operations within the machine. Some examples of this "Shorthand" language are BASIC (Beginners' All-purpose Symbolic Instruction Code).

Behavioral Objective.--A statement that specifies precisely what behavior is to be exhibited, the conditions under which behavior will be accomplished and the minimum standard of acceptable performance. These are sometimes called criterion objectives.

Branch.--In programmed instruction, a point of choice at which students are sent to alternative items depending on their responses to a particular item. Usually correct responses send a student on to new information. An incorrrect response would send the student to an item which provides information as to why his/her choice was incorrect. It could also supplement previous data.

Bypassing.--In programmed instruction, a technique which permits a student to skip certain portions of the material because of prior knowledge. A criterion item may be inserted in a linear program and, if the student passes it, he/she is sent forward several items (bypassing); if he/she fails the criterion item, he/she takes an intervening sequence of review or remedial items.

CAI.--A computer assisted instruction system which has a continual input/response capability for a lesson under study between the student and the computer. A conversational mode of presenting information and recording responses. An interactive system.

Chaining.--The linking together of a series of discriminable responses in a particular order. The completion of each response provides the stimulus for the next response. May involve chains of verbal responses (reciting a list of numbers or key words) or chains of motor responses (following a procedure). The connection made between an input (stimulus) and an action (response). For instance, giving directions on a tape slide series regarding the operation of a piece of equipment which requires the student to do the things stated as the procedure is presented.

CMI.--Computer managed instruction is a system whereby records, test scores, grading progress and support data are processed and stored for future use on a non-interactive basis by the teacher. Managing the instructional system rather than presenting lesson concepts.

Computer Language.--In order for a computer to provide the capabilities of an interactive system, the following requirements must be met: it must have an input terminal, a processor and an output terminal. Each language has its own characteristics and restrictions. For example, BASIC was developed for engineers, who were not familiar with the machine language of the computer but wished to make calculations and check problem solutions written in a more difficult programming language. BASIC, gives the computer a simple command, which then initiates many steps or separate commands within the computer. This process simplifies computer operator knowledge requirements.

Confirmation.--Notification to the student of the correctness of his/her response immediately after the response is made.

Cognitive Activities.--Activities associated with learning and the subsequent use of specific facts, procedures, decision skills, etc.

Conventional Instruction.--Presentation of educational information by an instructor to more than one student at a time using lectures, discussions, demonstrations and performance in a classroom.

Criterion Frame.--In programmed instruction, item(s) which appear at the end of instruction that contain no prompts. Intended to give evidence that the criterion behavior has been acquired.

Criterion Objective.--The specification of behavior which satisfies a job performance requirement, concerning precisely what behavior is to be exhibited, the conditions under which behavior will be accomplished and the minimum standard of acceptable behavior.

Curriculum.--Specific course or courses. Relating to a particular area of study an electronics curriculum would consist of all courses offered to complete, say, TV repair.

Discussion Method.--A method of instruction in which the instructor uses questions to create a learning situation in which students can take part by exchanging ideas, opinions and experiences to reach conclusions that support learning objectives.

Educational Technology.--The applications of principles of modern behavioral science and technology to education.

Entering Behavior.--The student's level of knowledge or skill before instruction begins. In programming terms, sometimes stated in or as enabling objective format.

Feedback to Student.--Information given to the student regarding the quality of his/her performance. Usually in instructional mode but could be referenced in management mode.

Feedback to System.--Information obtained from student responses which may be used to make adaptive instructional decisions or to revise the instructional program.

Frame.--In programmed instruction, each portion of material to which a student makes a response. A frame might also be called an exercise, a step or an item of information. It may vary in size to a single incomplete sentence to a sizable paragraph. A unit of control used by TIME which can contain up to 31 lines of information.

Generalization.--Learning to respond to new stimulus similar, but not identical, to one that was present during original learning. An attempt to conceptualize learning.

Hardware.--The physical components of a system which are utilized in instruction such as audio visual devices, terminals, computer storage systems and teaching machines.

Individualized Instruction.--A course of study or program fitted to the individual learner's background, abilities and needs, in which the learner has some input into the selection of materials and proceeds at his/her own pace.

Instructional Reliability.--The instruction obtained from the computer or program gives the same general results each time. Is the learning outcome consistent for those who experience the instruction?

Instructional Strategies.--The series of decision structures, such as media selection, pacing, difficulty level, readability level, etc., which determine the dynamic nature of instruction.

Instructional System.--An integrated combination of resources, techniques and procedures required by the student to achieve specified learning objectives.

Instructional Validity.--The instruction obtained from the computer or program actually allows the learner to reach and perform the terminal objective set prior to instruction. Is content directly related to purpose?

Learning Objective.--The specification of instruction goals which defines terminal behavior, minimal standards for acceptable performance and the conditions under which it is to be performed.

Lecture Method.--Oral presentation of educational facts, principles and ideas by the instructor.

Linear Programming.--A programming method in which set sequences of frames require a response from the student at each step. The steps are so designed that errors will be minimal for even the slower students in the target population. Every student does each frame in the program, his/her progress differing from that of other students going through the same program only in rate at which he/she proceeds through the sequence.

Measurement, Criterion Referenced.--The process of determining, as objectively as possible, a student's achievement in relation to a fixed standard which is based on criterion objectives.

Measurement, Norm Referenced.--The process of determining a student's achievement in relation to other students. Grading "on the curve" involves norm referenced measurement.

Measurement Test.--A written, objective type test designed to measure knowledge as applied to specialty tasks.

Module.--An entire instructional unit developed via a systems approach which teaches a specific learning objective or performs a specific evaluation process.

Motor Skills.--Those requiring manual dexterity, such as movement involving fingers, arms or legs.

Multi-Media.--More than one medium--texts, programmed instruction, audio and video tapes, slides, films, television, computers--used to convey the content of instruction.

Multi-Track Course.--A course which employs more than one track or channel of instruction. Course goals are the same on all channels, but course context, degree of instruction and presentation all vary to accommodate students of different aptitudes and levels of previously acquired skills and knowledges.

Off-Line.--The part of a system which is not under the direct control of the central processor.

On-Going Evaluation.--A continual process of evaluation leading to constant updating and revision of instructional materials.

On-Line.--The part of a computer system which is under direct control of the central processor.

Performance Activities.--Activities specifically related to performance on actual equipment such as laboratory work and supervised motor activities or performance of any job task.

Prerequisite.--The behaviors a student must have acquired before he/she can acquire specified new behaviors.

Programmed Instruction.--A student-centered method of instruction which requires the student to make active responses to instructional materials, provides immediate confirmation of the student's accuracy, allows the student to progress at his/her own rate, and is tested and revised before publication on the basis of student response.

Prompt.--A cue or stimulus added to the terminal stimulus of a frame in a program or presentation to make the correct response more likely while the student is learning. It may be pictorial or verbal. It may vary in strength, that is, provide a model for copy or provide a hint of a weaker sort.

Response, Covert.--An internalized response which the student presumably makes but which is neither recorded nor otherwise available to an observer. (Example, student thinks a response.)

Response, Overt.--A student's oral, written or manipulative act which is, or can be, recorded by an observer.

Response Analysis.--Study of student's response in terms of its correctness or incorrectness.

Response Collection.--The recording and storing of student responses to instructional materials.

Self-Paced Course.--A course consisting of materials and activities that allow a student to complete a course at his/her own rate.

Shaping.--A technique which reinforces successive approximations, starting with behavior that is already present (questions which can already be answered). Gradually, more difficult material is presented and more sophisticated answers are required.

Simulation.--A technique whereby "real-world" phenomena are reproduced. The simulation may focus on a small part of the features of the actual real-world situation. Simulation differs from another technique, gaming, in that rules and role playing typically do not take place.

Simulator.--Any machine or apparatus that simulates a desired condition or set of conditions.

Software.--The technical data, programs and language components of an educational system, as opposed to "hardware" components. The computer and terminal are hardware; the computer program is the software.

Standard of Performance.--A criterion used to determine whether the student has achieved the minimum satisfactory level of performance.

Student Critique.--Student feedback to course developers and administrators concerning a given unit or block of instruction.

Systems Approach to Instruction.--The series of procedures employed by educational psychologists, instructional technologists and curriculum developers to design and evaluate instructional programs.

Task.--A unit of work which forms a significant part of a work assignment done by an individual.

Task Analysis.--A study of the definition and interrelationship of skills necessary for a particular job, derived by reducing that job into its subordinate tasks and corresponding behavioral requirements.

Terminal.--An input source where data can be placed into and taken from a computer. In CAI, a classroom may have one or more terminals to gain access to the computer.

Unit.--A subdivision of a block of instruction that is complete within itself and can be taught as a whole. In programming terminology, sometimes called a "set."

Limitations of the Study

Because computer assisted instruction and computer managed instruction are often used interchangeably where they shouldn't be and because in every day use mini computer and micro computer are referred to in educational applications, for purposes of this study the following limitations will be adhered to by this study.

1. The hardware used in the classroom was an Altair 8800 micro computer with two floppy disk drives. The CPU had 64K-BYTES of memory, four 16K-Byte static boards. The inputs (four) were handled by a vector interrupt board and real time clock. The four ports were identified as follows:

   Port 16 -- was an ADM-1 Lear-Siegler CRT operating at 1200 BAUD.

   Ports 18 and 20 -- were ADM-1 and ADM-1A Lear-Siegler CRT terminals operating at 9600 BAUD.

   Port 22 -- was a digital equipment Decwriter II printer/terminal operating at 300 BAUD.

   The total cost of the system was under $10,000.

2. The computer language used was Altair time/share extended disk basic, version 1.1 preliminary release. The disk programs and data stored

on them was in Altair 4.0 extended disk basic, saved in the ASCII mode to be compatible with Altair time/share basic.

3. Information from the participants in the study was obtained from survey instruments administered prior to and after instruction on the computer. The respondents were selected on the basis of their enrollment in classes which were required for industrial arts majors and/or elective general education courses. All participants were pre- and post-tested as to their electronics knowledge over the course work covered (IAT 180, 3 hrs.; IAT 281, 3 hrs.; IAT 480, 5 hrs.; IAT 485, 3 hrs.).
4. The participants were given an opportunity to choose between other modes of instruction including video tapes, 16mm films, teacher lectures with demonstrations, traditional textbooks, commercial programmed texts and audio-tutorial laboratory activities. These modes were used in combination with, prior to or exclusive of the computer lessons, based on student choice.
5. The data collection extended over a time period of 27 months including seven quarters of class offerings from March 1978 to June 1980. Summer quarters were excluded from the data collection

as it was assumed that these students would not be compatible with those of the academic school year because of a greater number of graduate students.

6. The lessons taken by the students were selected from the 70 generated by the instructor, D. L. Jelden, over the course work covered in four courses and 14 quarter hours of undergraduate credit at the University of Northern Colorado.

CHAPTER II

RELATED LITERATURE

The related literature on computer assisted instruction for this study was divided into several categories. These categories were: (a) formally generated at the university level, military and technical school experimental programs and (b) general publications expressing views about computer assisted instruction and its future application. An attempt was made to discuss and summarize the results obtained from each. It should be noted that each source yielded a unique contribution toward addressing the purpose of this study.

A thorough search of the following data bases provided information about computer assisted instruction and computer managed instruction:

Educational Resource Information Center Dialog (ERIC)
Dissertation Abstracts International Datrix
The Readers Guide
Current Index to Journals in Education (CIJE)
National Technical Information Service (NTIS)
ERIC's Pacesetters Index

Many of the sources dealt with the large million dollar installations. A few were concerned with the mini system which sold for around $100,000. Several addressed themselves directly to the micro computer as an instructional tool.

General Publications Language

One main concern of several publications was addressed to the kind or type of language which should be used in communicating with the computer. This study did not address itself to looking at or comparing the pro's and con's of the specific languages which could be used to communicate with the computer. Through conversations and related presentations, the Dartmouth "Basic" was very often referred to. As the most often mentioned language for the non-technical students and for the beginning programmer, it was decided that basic would probably be the place to start with this micro system, since all of the hardware manufacturers contacted and general publications indicated it probably was the most universal.

Other language systems mentioned were: TUTOR, IDF, PILOT, PLANIT, ASET, IBM'S COURSEWRITER, TIME, PASCAL, APL, FORTRAN and COBOL. Some of these were specifically written for the interactive CAI application. IBM'S COURSEWRITER, TIME (McDonnel-Douglas TIME/SHARE), TUTOR, IDF, PLANIT, and PILOT are examples. These languages were a bit complex for the micro computer and no adequate system of conversion was available at the time this study was started. For this reason, BASIC was used.

CAI languages are often identified as authoring languages. They help the CAI lesson author in several ways: they provide a structure or a form for presentation of course content; they provide a simplified means of telling the computer what to do; and they provide facilities for answer-matching, recordkeeping and the like. While these languages do reduce time used to code lessons, they help with only a small part, perhaps 10 percent, of the total authoring process. Since the program computer language was a small part of the overall authoring process, it was felt that BASIC would provide the necessary flexibility in a beginning or feasibility study. It was thought the effort should be placed on improving the total process of authoring as well as coding.[1]

Theories of Learning

To establish a sound base educationally for applying the computer as an instructional tool, as effort was made to relate the latest and the best available regarding the psychology of learning to computer assisted instruction. As gleaned from basic concept books on the psychology of learning, three factors were identified as being compatible with CAI and supportive of it.

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[1] "Pipeline," Conduit, Vol. 3 No. 3 (Summer 1978): p. 15.

I. Principles Emphasized Within the S-R Mechanistic Theory of Learning

A. The learner should be active rather than a passive listener or viewer.

B. Frequency of repetition is still important in acquiring skill and in bringing enough overlearning to guarantee retention.

C. Reinforcement is important and repetition should be under arrangements in which correct responses are rewarded.

II. Principles Emphasized Within the Gestalt, Cognitive or Concept/Principle Theory of Learning

A. A learning problem should be so structured and presented that the essential relationships are open to the inspection of the learner.

B. The direction from simple to complex is not arbitrary, meaningless parts to meaningful wholes, but instead from simplified wholes to more complex wholes.

C. Learning with understanding is more permanent and more transferrable than rote learning or learning by formula.

III. Principles From Personality Theory of Learning

A. The learner's abilities are important and provisions have to be made for the slower and the more rapid learners.

B. The anxiety level appears to be important in determining the beneficial influence of praise or blame.

Computer assisted instruction has the flexibility and capacity for individualizing instruction. Three of the above characteristics of computer applications in instruction make this possible: (1) active responding by the student; (2) continual evaluation of the students' responses; and (3) adaptation of the instruction to individual responses, levels of achievement, and specific interests of the student.

Historical Background of CAI

Sidney Pressey in the early 1900's and B. F. Skinner in 1954 provided some of the earliest attempts to "automate" instruction. Both Pressey and Skinner developed techiques of administering instructional materials to students by means of teaching machines or programmed texts. Much of Skinner's work was based on his experimental studies in training pigeons to perform simple and complex tasks. Skinner soon discovered that programmed texts and teaching machines were extremely limited in the extent to which they could adapt to individual differences. He also noted an inability to continually provide a stimulating responsive environment for students. The obvious limitations of these devices prompted investigation into the more sophisticated machine, the computer, as an instructional device.

In 1959, researchers at IBM developed a course to teach stenotyping and binary arithmetic by computer. At the same time, refinements were being made in computer systems, terminal hardware and the number of terminals a computer could support. By the early 1970's systems were in existence which could support as many as 200 terminals simultaneously.

One of the basic problems in the early development of computer assisted instruction was that most systems were built around modified business computers and terminal devices. The use of modified business equipment resulted in equipment which was not appropriate for instructional purposes. An analogy might be an individual who purchases a Greyhound Bus for use as a family car. It could do the job, but it isn't very practical.

In 1966, IBM announced the development of the 1500 instructional system. The first production line model was delivered and installed in December 1967. The IBM 1500 system was the first computer system which was designed and developed specifically for instructional purposes. The systems developed prior to that time utilized electric typewriters or teletype terminals. The systems designed specifically for instruction have utilized the cathode ray tube (CRT) terminal as the major display device. More complete systems include random access audio, playback/record capability and random-access image projectors, all under program control.[2]

The advent of the mini computer in the early '70's by Wang, Hewlett-Packard and others reduced the cost of computer hardware by 90 percent. It also reduced by about the same amount the level of support material sophistication. However, with a drastic reduction in cost, the computer became economically feasible for many of the very large and well financed school districts.

With the development of the microprocessor chip, the micro computer became a reality in the middle to late '70's. By 1979, it was possible to purchase a complete micro computer system with keyboard, display terminal, cassette tape storage and program capability for under $600.00. What are the implications of the home computer for education or the micro computer as an interactive instructional tool? This is the major thrust of this study.

It is obvious that the widest benefits of the electronic revolution (unlike most revolutions) will accrue to the young. Seymour Papert, Professor of Mathematics and Education at Massachusetts Institute of Technology, estimates that there will be five million private computers in people's homes and available for student use by 1980; by 1982, he predicts 80 percent of the upper middle class families will have computers capable of playing important roles in the intellectual development of their children.[3]

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[2] Phi Delta Kappan, Vol. II, Number 10 (June 1971), p. 629.

Robert Albrecht, a pioneer of electronic education, says that in schools, computers will be more common than carrousel slide projectors, movie projectors and tape recorders. They'll be used from the moment school opens, through recess, lunch hour, and as far into the day as the principal will keep the school open.

The greatest drawback in applying computer technology to education is not the technology or hardware, but the software--the development of the instructional program. The development of micro systems and their reduced cost will necessitate that teachers be taught the rudiments of some simplified programming language and how to write valid and efficient instructional computer programmed lessons. Although this study will not deal directly with this specific problem, a cursory overview will be given on how to proceed with the development of an instructional lesson, as data from this study had to originate from a teacher-made instructional program. A few do's and dont's might be of value to novice programmers. More on that in Chapter III on methods and procedures.

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[3] "The Computer Society," Time, special section (February 20, 1978), p. 48.

Formal Research Studies (Hardware)

The hardware and required interfaces essential to generate a micro computer interactive system were not available as a total package until Thompson developed one based on pre-selected criteria in 1977.[4]

His study was prompted by the continuation of educators to expand the multi-media environment and the rapid growth of the micro computer industry. These two factors provided an opportunity to meld them into an educational application which possibly could improve the work of the school. Teaching has long perceived that to leave any teaching tool unutilized is to live beneath its privilege, and that the profession cannot afford to leave any beneficial educational tool untried.[5] The computer, since its inception, has become more and more beneficial as a useful tool in education to promote progress.

The main thrust of Thompson's study was to develop a practial low-cost micro computer system capable of interactive computer assisted instruction which would be multi-terminal (four) and could be used in an average classroom by teachers who were not computer language specialists. He also set $10,000 as the maximum dollar limit for such a system.

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[4] Llcyd D. Thompson, "The Feasibility of a Micro-Computer System for Computer Assisted Instruction in Electricity/Electronics," Unpublished doctoral dissertation, University of Northern Colorado, Greeley, 1977, p. 92.

[5] Lester B. Sands, Audio-Visual Procedures in Teaching (New York: Ronald Press Co., 1956), p. 4.

After a thorough search of micro computer manufacturers to determine availability and capability, the MITS micro computer was chosen. It provided most of the hardware requirements and interfacing techniques essential for such a system. It also could be purchased in kit form for modification into an educational format. The main consideration of the system was that it must be standard in memory and interface peripheral compatability so expansion of the system could be achieved at a later time. The MITS system met these requirements. Based on Thompson's study, it was concluded that such an interactive CAI micro system could be built well within the guidelines of cost and operator expertise. The research data generated in this study were compiled on the following system assembled and modified by Thompson.

An Altair 8800A, 64K BYTE main frame with bootstrap front loading operation was used. It has 4-port (terminal) access to two MITS (Pertec) floppy disk drives with 300K BYTES of memory each. The four terminals consist of three ADM1 Lear-Seigler CRT's and one Decwriter II Printer. The program language used was Altair Time Share Extended Disk Basic. This configuration provides independent access from each terminal to the central processing unit (CPU) and the disk drives by means of a vector interrupt board and a real - time clock. The Altair Time Share Basic provides for establishing independent partitions and priorities for each if the peripherals at the time of initializing or powering up the system. The core memory size of each partition can be determined based on need and program length. Observations about restrictions and operating characteristics will be reported in Chapter IV of this study.

Altair Modified Authoring Language

Although this study used the Altair Basic Language as its prime command code, another study by William K. Jackson, resulted in a nine statement mnemonic command code which could be used by teachers for lesson generation. This development occurred after this study was underway. As such, this programming language was not used but should be considered in future teacher oriented program development. It parallels IBM's Coursewriter II and Hewlett-Packard's mini system CAI format.[6] The author command codes with their definitions can be found in Appendix A of this study. A new CAI is also found here.

Experimental Operating CAI System

Because of the large numbers of students trained in the technical areas within the military, the attractiveness of CAI from both an economic and education sense was great. The Navy, Air Force and Army were all involved in some way or other in computer assisted or computer managed instruction. In assessing these programs, the one research study operated by the Army Signal Corps in electronics at Ft. Monmouth, New Jersey, was the most productive. They were using an IBM 1500 system to teach the basic electronics concepts to the signal school technicians. Their study involved traditional classroom instruction (CI) and computer assisted instruction (CAI) groups on a control basis. This four-year study netted the following results:

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[6] William K. Jackson, "A Computer Assisted Instruction for the Altair 8800 Computer," Unpublished doctoral dissertation, University of Northern Colorado, Greeley, 1977, p. 94.

1. CAI across aptitude levels, is as effective or better than CI with respect to the generally employed criteria of student achievement: written/performance tests and attrition rate.
2. CAI, across aptitude levels has the capability to reduce training time to a significant degree relative to average CI completion time.
3. CAI students on an average, are favorably disposed toward CAI.
4. The tutorial approach is a viable instructional method in the presentation of CAI materials in U.S. Army Basic Electronics.
5. CAI is a viable instructional system within an operational army training milieu.[7]

Based on these conclusions from the operation of the IBM 1500 series system, it was suggested that some of the same type of results might be obtained from a scaled down version utilizing a micro computer within a normal classroom environment. To initiate the system development and to assure some instructional relationships, close association was made between the instructional lessons (script) of the army experimental study and the ones employed in this study. Some modifications had to be made in the support audio-visual materials as the micro computer does not have the management sophistication of the IBM 1500 system. Also, additional technological developments in electronics required the modification of existing lessons and the development of additional lessons (scripts) of the army experimental study. Original scripts were generated in solid state and digital electronics. A total of 70 lessons were utilized in the study.

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[7] A Summative Evaluation of Computer Assisted Instruction in U.S. Army Basic Electronics Training, Technical Report 72-1, U.S. Army Signal Center and School, Ft. Monmouth, New Jersey, May 1972, pp. vi-vii and 43-47.

All of the military instructional lessons had to be recoded into basic commands and statements and reorganized into limited instructional frames compatible with the Altair system. In addition, the visuals in strip film form from the 1500 system were completely modified into a picture book which could be used as a supplemental visual reference to the Altair computer instructional lesson. It was hoped that the general findings of this study would mutually support the results obtained in the army experiment.

Summary

In the main, research has already indicated the vailidity of computer assisted instruction.[8] However, due to the complexity of the computer hardware and the indicated high cost of owning the large or mini systems, incorporation into the individual classroom has been done on a very limited basis. For example, in a study done in 1976 of over 200 industrial arts departments in higher education, only forty-seven (47) indicated that computers were used in some form or other in instruction. Of these, only eight (8) were classified as mini computers. Not one response mentioned micro computers.[9]

Because microprocessors were very new to education, there presently exists a definite void of any current research concerning usage capability. On the other hand CAI should not be regarded as a technique of the far future. We stand today at the threshhold of practicability with regard to the technique. Previous research and developmental processes employed with this study have convinced many that a practical means of working with CAI could soon be made available to a much larger community than hitherto.

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[8] John D. Ford, Computer Assisted Instruction in Navy Technical Training Using a Small Dedicated System, Final Report, Naval Personnel Training Research Laboratory, U.S. Department of Defense (Washington, D.C.: Government Printing Office, 1976), pp. 1-69.

[9] Joseph F. Thomas, "An Analysis of Computer Assisted Instruction in Undergraduate Industrial Arts Teacher Education Institutions," Unpublished doctoral dissertation, University of Northern Colorado, Greeley, 1976, p. 99.

The broad adoption of CAI need not wait hypothetical future major breakthroughs in technology. Instead, the rate of adoption will be primarily determined by the rate at which resources are applied to develop software and inform potential users of the necessary system methodologies and pedagogical techniques.[10]

Research has shown that micro computers can be inexpensive, simple and a basic tool for education. Microprocessors coupled with conversational programs can be made both simple and inexpensive. One does not need to be a computer expert in order to integrate a computer into the curriculum. One needs merely the desire to progress.

Although the computer has the potential to reduce the costs of education and improve productivity, its greatest advantage is freedom to work on an individualized basis with each student to improve the quality of our existing educational program.[11] Previous research has consistently shown that the same amount of material has been learned in a CAI environment as in a conventional classroom, although with a considerable savings in time in favor of CAI.[12]

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[10] E. N. Adams, "Computer Assisted Instruction," Computers and Automation, March 1966, p. 41.

[11] Andrew R. Molnar, "Viable Goals for New Educational Technology Efforts in Science Education," Educational Technology (September 1975), p. 21.

[12] Keith A. Hall, "Computer Assisted Instruction: Problems and Performance," Phi Delta Kappan, Vol. II, No. 10 (June 1971), p. 631.

CHAPTER III

METHODS AND PROCEDURES

Introduction

The main purpose of the study was to evaluate the micro computer as an interactive instructional tool which could be used by the average classroom teacher. To do this, several preliminary steps had to be taken.

First, the system had to be physically constructed or obtained from commercial suppliers. This phase of the project was accomplished by Lloyd Thompson as part of a formal research study done in 1975-76 at the University of Northern Colorado.

Second, the capabilities of the system had to be explored and a determination made of operating limits, both in terms of the computer language to be used and the capacity (flexibility) of the system. A sample lesson was generated to see how the CRT display should be set, to determine the core limitations of the central processor system (CPU memory available for programming), to establish the maximum number of lessons which could be stored on a single floppy disk and to determine the read-write access time for program retrieval from each operating terminal. In addition, some estimation had to be made regarding the type of management functions which could be performed by the system in addition to the instructional program. An effort was made to make the microprocessor system more than a "page turner" for presenting information. Branching and record keeping were an important part of the system. This developmental phase took about 12 months. The results of this effort have been reported in the first part of Chapter IV in the findings of the study.

CAI Materials Creation

The materials which were written for the micro CAI system were generated from a user's standpoint. Emphasis was placed on creating lessons which have immediate application to the ongoing educational program in the industrial arts and technology electronics offering at the University of Northern Colorado. To accomplish this, the program was developed in line with these general guidelines:

1. Course materials must be over content compatible with the existing course of study and supplemental to, 16mm films, video tapes, traditional texts and laboratory activities already in use.
2. Any materials generated should be teacher made and should be within the capabilities of the traditional theories and concepts taught in the existing professional teacher education preparation program.

3. The instructional strategies and procedures must have proven merit and be supported by valid experimental research as worthwhile.
4. The cost of developing course materials must be within the realm of possibility for the average classroom program and should not place an undue financial burden on the teacher, the school administration, or support personnel.

First, attention was focused on the instructional process in terms of class or course objectives. These objectives were derived from an instructional analysis of textbooks in the field and verified by industry as the basic content for a general understanding of electronics prior to any degree of specialization. Only those topics which were considered by industry as "required" or "preferred" information were included in the course outlines.[1] These performance operations and their related topics of information were then written in general terms to help guide the lesson development. Performance objectives were then developed in order to provide a means of evaluating the skills and knowledges taught by each lesson. Course materials were generated which complied with stressing practical or "hands-on" learning in the laboratory.

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[1] Jelden, 1960.

Second, the development of the course materials must be done by the person responsible for teaching and evaluating the class. To begin with, preparation of course materials would be more valid if the lessons closely paralleled the traditional class offering. Also, if the person using the material wrote it, then altering of its presentation and content could be done on a continual basis and revisions/additions and/or updating could be quickly incorporated.

Based on the experience of this program and on data obtained from previous research, the development and implementation of course material is well within the competency of the classroom teacher. This would tend to support the implications for large scale applications in most all classroom environments.

Third, because this system was predicated on a user development effort, the instructional model must be limited to strategies and procedures of proven merit. We are mindful of the great amount of research being performed to increase the sophistications of the instructional strategies and techniques that can be incorporated in a CAI system. A prime example of this work is the instructional decision model from project IMPACT conducted by HumPRO or the plasma screen technique utilized in PLATO. These and other ideas should be incorporated into our micro system where feasible. A preliminary investigation showed that the limitations of the hardware excluded their use. Instead, an emphasis was made to incorporate the ideas found in tried and proven programmed instruction handbooks, such as the Handbook For Programmers of Automated Instruction by Melching, Smith, Rupe and Cox, U.S. Army Air Defense Human Research Unit, Ft. Bliss, Texas, September 1963 and the Handbook for Designers of Instructional Systems, AFP 50-58, Volumes I, II, III and IV, Department of the Air Force, 30 Janaury 1974.

Finally, serious consideration was given to the economics of preparing CAI course materials. In response to this guideline, a practical approach was implemented which allowed for the development of each lesson and a trial period over an 18 month time block in actual class settings. Graduate students, beginning students and some highly qualified personnel in electronics were asked to take CAI lessons and make comments on things they thought should be clarified or expanded. This process, accompanied by a University of Northern Colorado staff member specializing in electronics reviewing the lessons validated the technical content of the scripts. No outside consultants, authors or specialized personnel were hired to augment the development of the instructional scripts. Some funds were paid to work-study personnel to type the data into the comptuer for storage on the disks. This amount of money was under $1,000.00 over a three-year period. These funds came from the

University's research and publications grants at the University of Northern Colorado.

The objectives for each lesson, which were described earlier, were used to specify the "enabling" objectives which listed the skills and knowledges necessary to the development of the desired terminal behavior. The enabling objectives provided a means of allowing each student to judge for themselves whether or not they were ready to begin the study of the proposed lesson or if some additional preparation was needed. Throughout the lessons, an attempt was made to place more responsibility for progress and procedure in the hands of the student. The prime thrust was to make each student an apt learner and efficient as an individual in obtaining information.

Lesson Preparation

The first step in developing a CAI lesson, was to organize the terminal performance objectives into course segments. A course segment encompassed a group of related topics and employed several teaching methods such as tutorial dialog, on-line and off-line activities and achievement measures. The course segments were subsequently subdivided into lesson modules. The instructional programmer took these modules and generated the lesson script. At the same time, notations on the visual or graphic displays were made. These sketches and their accompanying scripts indicated the multi-media character of the CAI author. In addition, the author needed to be a programmer and be familiar with the computer language used to execute the instructional program in order to code, test and debug the lesson.

The lesson was individualized by providing branches based on aptitude levels and the accuracy of the student's response. This strategy was defined by the instructional model and conformed to the established guidelines which follow:

1. An area provided for text of 40 characters wide and 12 lines in length (1/2 screen width for an 80 character CRT display). This was done to allow split-screen operation at a later time.
2. Each response frame had at least two alternatives, with preference given to four. More alternatives allowed for more discrimination in achievement levels.
3. Response items needed to be answered with single letter or number items. This reduced the chances of input or "cockpit" error as the answers were given.

Each lesson module consisted of an introduction, a listing of the performance objectives, the enabling requirement if applicable, a pre-test with scoring capability, a lesson module, a lesson review and a post-test. The pre-test was used to permit a high or middle aptitude student to advance to the next lesson if they demonstrated sufficient prior knowledge (80 percent on exam). The lesson post-test items were used to ascertain if the desired terminal behavior was developed by the lesson element.

The instructional programmer should follow a general procedure in the preparation of the lesson:

1. The lesson objectives and enabling objective are written.
2. The pre-test and post-test items are written.
3. The lesson element is written.
4. The support visual or sketches are made as the script is written.
5. The computer code is added for input into the system.
6. The lesson is typed, edited and saved on floppy disk in the system.
7. Student trials and technical validation are given.
8. Revision and alteration of visuals, lesson elements or evaluations are made.
9. Lesson is implemented in actual classroom operation.

Implementation does not divorce the instructional programmer from further responsibility to the lesson. Data was accumulated on each lesson as students go through the course. These data were periodically analyzed to find areas within each lesson that may required modification. Unlike a textbook, CAI lesson material can be altered with relative ease and feedback quickly generated to reflect the effect of the changes. Thus, even though the lesson was implemented into the mainstream of teaching, the dynamic character of a CAI system readily lent itself to immediate adaptation to changes affecting the student input or course content.

Program Coding

The first hurdle which the potential CAI educator faces is that of learning a CAI language. Employing the one person concept, the educator/author/instructional programmer had to become adept at using the CAI language and proficient in using its programming techniques. It is argued that the instructional programmer need not have an indepth technical competency in the CAI language, but rather, that they should deal with concepts in solving their instructional problems. To a degree, this proved true. The use of Altair Extended Disk Time Share Basic simplified the actual script coding.

The management programming was accomplished by a computer system programmer, Dr. Carl Crosswhite, from the Computer Center at the University of Northern Colorado. In consultation with him and under his direction, a management test scoring, recording and reporting system was developed. This was also programmed in basic computer language. A copy of the management programs as well as a sample lesson can be found in Appendix B of this study.

Altair CAI

Although this experimental study did not use a macro system CAI computer program, as a separate study during the data collection stage of this research, a type of "coursewriter" was generated by William K. Jackson in the fall of 1976. A copy of this program is also found in Appendix A of this study.

The main advantage of a macro programming system was a reduction in the number of programming statements used in coding an instructional script. For example the entire lesson can be coded with nine mnemonic, two character codes as follows:

QU -- The presentation of a question the text portion of the entry will be requested.

QB -- The same as QU except that the question will be graded.

CA -- A correct answer. The text portion of the entry is compared to the answer supplied by the student.

WA -- An anticipated wrong answer. The text portion of the entry is compared to the answer supplied by the student.

UA -- An unanticipated answer. This command provides a logic point for answers supplied that are not CA or WA.

DS -- Display or text at a major level. This command causes the text portion of the entry to be unconditionally displayed.

TX -- Display of text at a minor level. This command causes the text portion of the entry to be conditionally displayed. The condition for display is a match on the preceding CA, WA, or UA statement only.

BR -- Unconditional branch. This operation will cause the lesson to resume at a position in the lesson other than the next major statement in sequence.

LB -- Course labeling or segmentation. This command allows the course to be broken into segments and assigns a name to each segment. This feature allows a pointer to be created for branching and reentry into the system.[2]

Future developments and new lessons might be simplified if this type of CAI coding system were used.

Instructional Model Development

The instructional model used in the preparation of CAI lessons for this research study was based on the one developed by the U.S. Army Signal Center and School, Ft. Monmouth, New Jersey and detailed in Technical Report 71-2, May 1971, entitled An Instructional Model for

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[2] Jackson, pp. 4-5.

Computer Assisted Instruction, 19 pages. An overview of that model as it was applied in this study will be presented in the following few pages. Modifications as applied in this study will be identified within the review.

The substance of computer assisted instruction was the instructional model which structured the interactive process between the student and the subject matter. Ideally this process should have been sufficiently comprehensive and flexible to accommodate every variable and contingency relevant to the achievement of learning objectives. Although the model described in no way purports to have attained this ideal, it has, nevertheless, demonstrated its practical utility in the successful application of computer assisted instruction (CAI) in an ongoing program.

The instructional model presented was basically a further evolution of the instructional strategies and techniques used in any good educational environment. In its current stage of development the CAI model remains an ever changing instrument. It is, therefore, subject to further modifications warranted by the experience with CAI materials developed in-house and by advances in the state of the art. The model reflected the degree of complexity that can be readily utilized in the instructional programming of electronics subject matter without extensive experimentation. This consideration was vital to the user development orientation of this CAI effort. The practical experience gained through this approach should provide valuable stepping stones for the evolution of valid and reliable models with higher orders of sophistication.

General Guidelines

It is not the intent of this presentation to delve into a detailed conceptualization of instructional models. This type of information can be found elsewhere. However, the development of a particular model, such as the one described here, does presume a specific set of strategies that govern the flow of information within the instructional system. It should also be noted that the curriculum presented by the instructional system should be derived through an instructional analysis of the subject area. Thus, the approach employed to develop the instructional model for user application of CAI is sensitive not only to the immediate instructional process, but to other factors which influence the process. This approach was embodied in a set of general guidelines as follows:

1. The content of instruction should be determined through content analysis and should be specified in terms of student performance objectives consisting of terminal performance and enabling objectives.

2. The pace of instruction should be controlled by the individual student to the maximum extent consistent with effective educational practice.

3. Individual differences among students should be taken into account providing the most effective and efficient learning paths in line with student aptitudes and needs.

4. Extensive use should be made of information feedback assuring response sensitive instruction.

5. The instruction should be presented in a modified single mainline track. Branching, looping and other techniques should be used to promote efficiency and effectiveness of instruction particularly for slow learners. Forward branching should be used to increase the efficiency of instruction for fast learners and others with prior knowledge of the subject matter.

6. A system should be established to evaluate student performance in terms of mastery of objectives.

7. Knowledge of results should be provided to the student. Correct answers should be confirmed and incorrect responses should be followed by immediate remediation.

8. Progress to a new increment of instruction should not be permitted unless a correct answer was obtained from the prior question.

9. Students should be afforded the opportunity to recycle through those portions of the instruction in which failure to meet objectives was evident.[3]

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[3] Albert J. Mizendo and Allyn A. Evans, An Instruction Model for Computer Assisted Instruction, Technical Report 71-2, May 1971, U.S. Army Signal Center and School, Ft. Monmouth, New Jersey.

10. The mainline sequence of instructional frames should be designed to achieve 85 percent correct responses by all students on the first try. Achievement of this objective should be determined through analysis of student performance data by trial and error in sample programs.

11. Effective use should be made of the instructor assisting students who encounter difficulty during instruction. The need for instructor assistance should be determined under program control by failure of the student to meet specified performance criteria. In addition, instructor assistance should be made available whenever requested by the student.

12. The instruction should consist of practical (hands-on) training to the extent dictated by the objectives.

13. Verbal and practical (hands-on) training should be carefully integrated to provide a variety in presentation modes and to avoid over-dependence on verbal comprehension for mastery of concepts and skills.

14. The major portion of the subject matter should be converted to a CAI format. However, care must have been exercised to avoid the use of CAI for instruction that could be presented just as effectively by more economical self-paced methods.

15. Liberal use should be made of graphics diagrams, schematics, etc., in conjunction with verbal presentation of subject matter. These have been assembled into a diagram book.

16. Vocabulary control should be exercised to keep reading comprehension requirements generally consistent with the reading ability of typical students. All programs have been written for the 10th grade level or below as determined by the FOG Readability Index.

17. Care should be taken to avoid lengthy presentations prior to a call for a student response. No more than three frames have been presented without some student response, exceptions being review modules.

Course Organization

The major components of the instructional model are shown in Figure 1. These components are organized in a manner to implement the guidelines established for the model. The definition and function of each component are as follows:

> Course.--The total organization of all subject matter, strategies and techniques designed to achieve specified levels of student performance in a subject area specialty or a major task or skill area. The terminal performance and enabling objectives for the course are derived through a systematic analysis of the subject specialty, task or skill area for which education is to be provided. A course can consist of as many phases as may be necessary to achieve all terminal performance objectives.

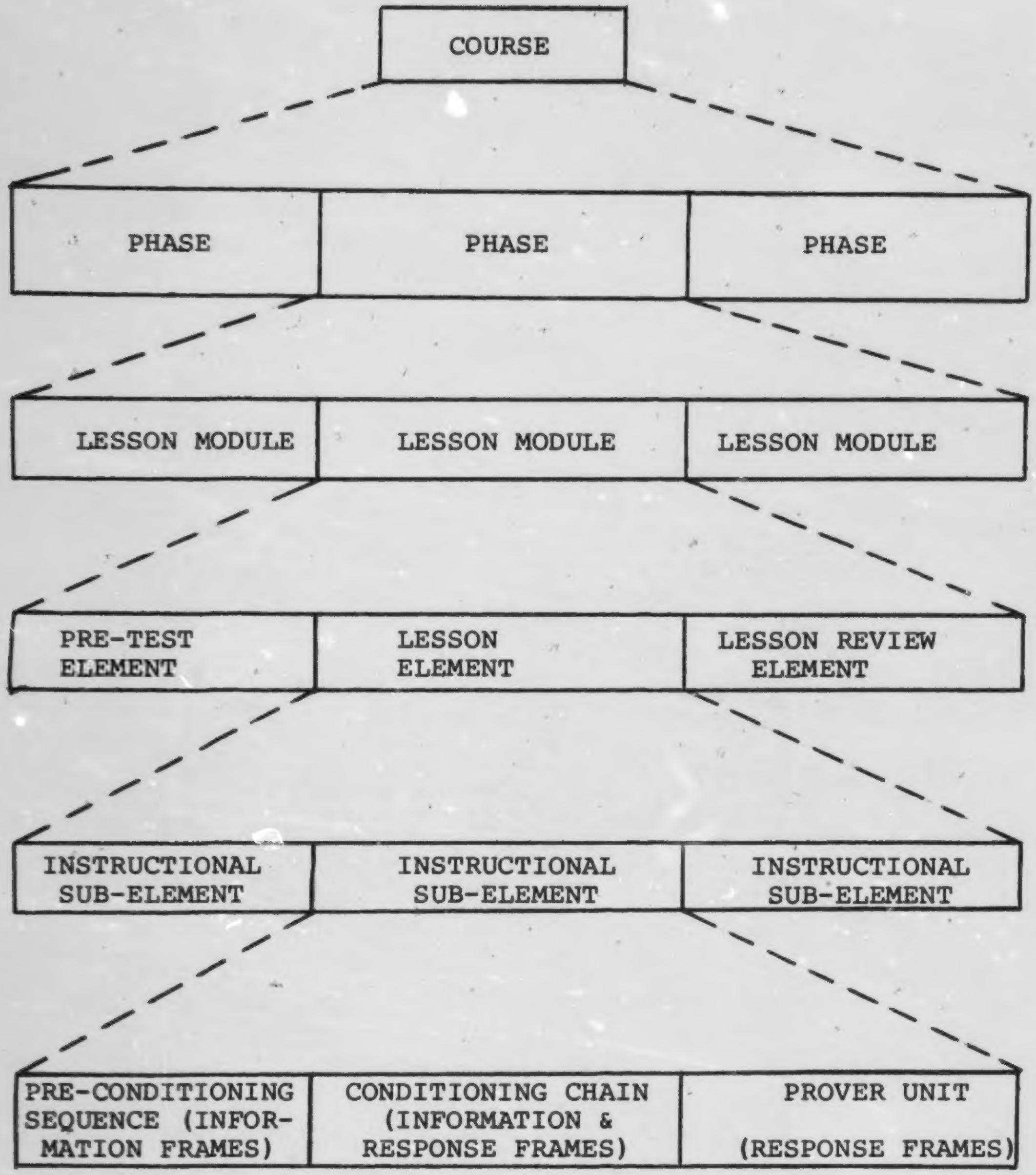
COURSE
PHASE
PHASE
PHASE
LESSON MODULE
LESSON MODULE
LESSON MODULE
PRE-TEST ELEMENT
LESSON ELEMENT
LESSON REVIEW ELEMENT
INSTRUCTIONAL SUB-ELEMENT
INSTRUCTIONAL SUB-ELEMENT
INSTRUCTIONAL SUB-ELEMENT
PRE-CONDITIONING SEQUENCE (INFORMATION FRAMES)
CONDITIONING CHAIN (INFORMATION & RESPONSE FRAMES)
PROVER UNIT
(RESPONSE FRAMES)

Figure 1[3]

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[3] Ibid., p. 4.

Phase.--(sometimes identified as a cluster of lessons) A major block of instruction within the course. Each phase is responsive to a subset of the terminal performance objectives for the course. A phase usually consists of a combination of CAI lesson modules and off-line practical exercises arranged in a sequence to facilitate achievement of the objectives. Each phase normally terminates in a written and performance test. The off-line practical exercises and phase tests are not discussed here because they are not presented in a CAI mode. However, it is planned that the phase tests will be incorporated into terminal performance objectives for the course. A phase usually consists of a combination of CAI lesson modules and off-line practical exercises arranged in a sequence to facilitate achievement of the objectives. Each phase normally terminates in a written and performance test. The off-line practical exercises and phase tests are not discussed here because they are not presented in a CAI mode. However, it is planned that the phase tests will be incorporated in the instruction and the practical exercises will be converted to a computer managed mode. It should be stressed that the lesson module in the current instructional model can be designed to provide "hands-on" learning and, in fact, this is the case in a number of the lesson modules now in operational use. Furthermore, it should also be noted that the current off-line instruction and off-line testing are self-paced in agreement with the self-paced nature of CAI. Keeping in mind that the instructional model in this pertains only to the CAI portion of the course, a phase is conceived as being made up of as many lesson modules as may be required to achieve the subset of objectives established for it. Phase evaluations are presently generated by another computer on a random selection basis unique for each student's program of studies.

Lesson Module.--A self-contained instructional unit designed to enable the student to attain specific skills. Being self-contained, a lesson module is the smallest "stand-alone" component of the course. It can, therefore, be used out of the context of the course to provide supplementary instruction in a specific skill area. Each lesson module consists of three elements. They are the:

a. Pre-test Element which enables a student to skip lesson material related to skills or knowledges he already possesses.

b. Lesson Element which provides the instruction for the achievement of the objectives established for the lesson module.

c. Lesson Review Element which tests for mastery of the objectives established for the module. This could also be called a post-test for the lesson.

Inasmuch as these three elements are the principal ingredients of the instructional model, they are treated independently and in greater detail later. As can be noted in Figure 1, the lesson element of a lesson module consists of instructional sub-elements each of which addresses a specific enabling objective.

Instructional Sub-Element.--The basic teaching unit within the model. Each sub-element consists of a:

a. Pre-conditioning Sequence to prepare the student for the instruction he is about to receive, a

b. Conditioning Chain designed to shape the student's behavior to achieve a specific objective, and a

c. Prover Unit to test mastery of the objective specified for the sub-element.

It should be noted that the pre-conditioning sequence consists only of information frames. This is consistent with the function of this sequence. The conditioning chain consists of both information and response frames in which cues are gradually withdrawn toward the end of the chain. The prover unit consists solely of response frames in keeping with its function.

Lesson Module.--Student progress through the course is essentially linear. That is, each student completes a phase before he proceeds to the next one. Although the military model used a very sophisticated management recycling system within the lesson module, in the micro system it needed to be simplified in order to fit the restrictions imposed by the micro system.

For practical considerations three aptitude levels were established to simplify individualization of learning paths through a lesson module. These were: High, Medium, Low

The general paths through a lesson module used in the military are shown in Figure 2. It should be noted that only high and middle aptitude students are permitted to take the pretest. Allowing these students to take the pretest increases efficiency of instruction by enabling them to bypass subject matter in which they have demonstrated competency achieved through past experience or through home study assignments prior to coming to class. Low aptitude students, on the other hand, are not permitted to take the pretest because experience has shown that these students generally do not have the requisite knowledge. Thus branching these students around the pretest tends to avoid an adverse effect on their motivation.[4]

In the micro model all students who fail the pretest proceed through the lesson element in linear fashion.

As indicated in Figure 2, all students who take and fail the lesson post test or review element can be recycled through the entire Lesson Element or given specific remediation. The option made available to the student is dependent initially on his degree of failure. Furthermore the final decision on the option to be executed rests with the instructor after a counseling session with the student. Because of the pre-selection offered by admission to a college program, in the microprocessor model, no "low" aptitude student paths were provided and all students were required to take the pre-test to verify their competence over the lesson.[5]

For the micro system, the specific levels of remediation and record keeping were not possible. However, wherever possible, the model was followed as closely as possible.

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[4] Albert J. Mizenko and Allyn A. Evans, An Instruction Model for Computer Assisted Instruction, Technical Report 71-2, May 1971, U.S. Army Signal Center and School, Ft. Monmouth, New Jersey, pp. 1-19.

[5] Ibid.

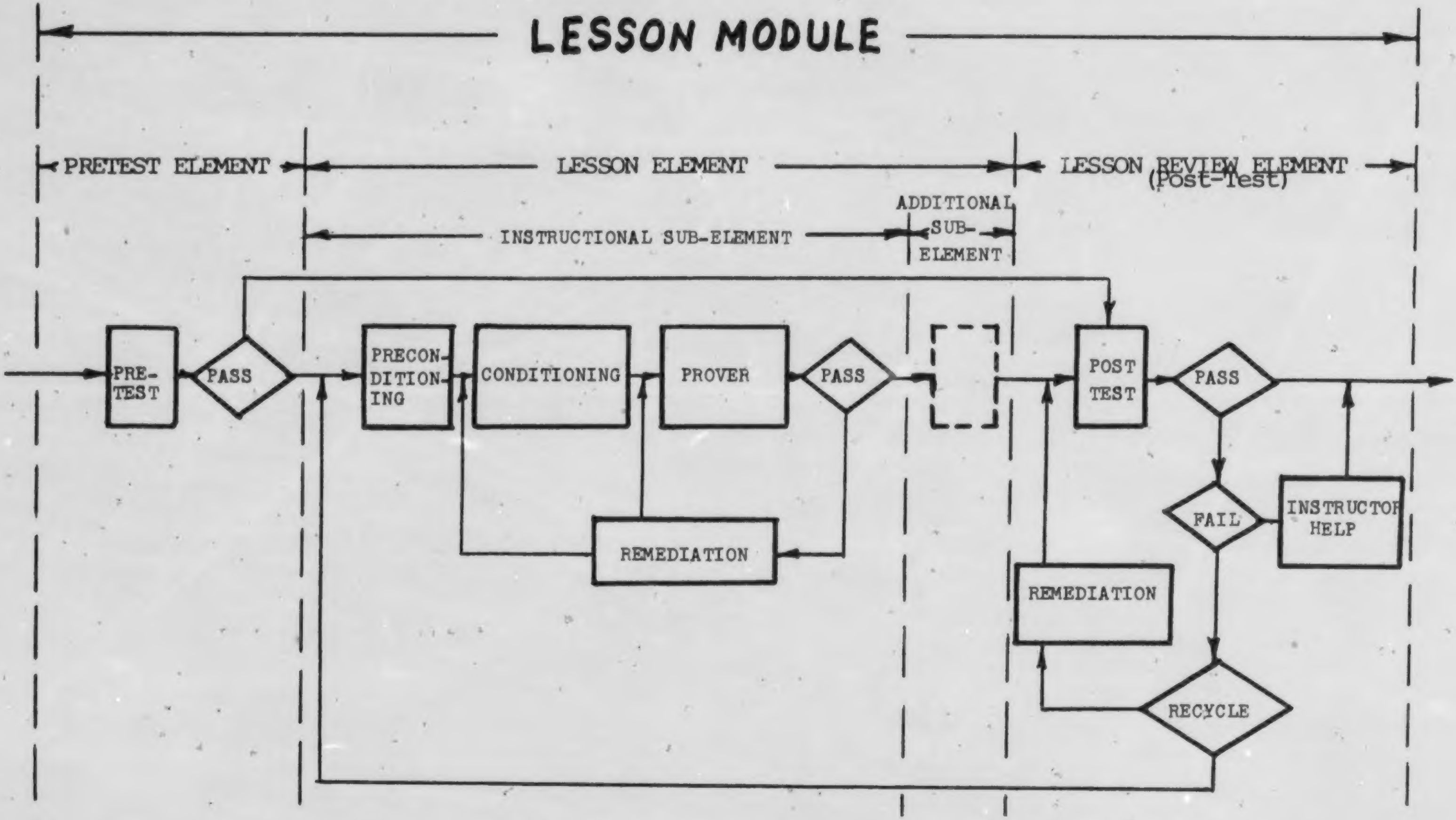
LESSON MODULE
PRETEST ELEMENT
LESSON ELEMENT
LESSON REVIEW ELEMENT (Post-Test)
INSTRUCTIONAL SUB-ELEMENT
ADDITIONAL SUB-ELEMENT
PRE-TEST
PASS
PRECON-DITION-ING
CONDITIONING
PROVER
PASS
REMEDIATION
POST TEST
PASS
FAIL
INSTRUCTOR HELP
REMEDIATION
RECYCLE

Figure 2. Modified Module Omitting Aptitude Level[6]

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[6] Ibid., p. 8.

Pretest Element

As pointed out previously, the pretest contributes considerably to increasing the efficiency of instruction. In order to provide assurance that this element of the module performs its task effectively, several guidelines control its construction. These include:

1. The pretest shall reflect the terminal performance and enabling objectives for the module and shall consist of test items which are alternate forms of the items used in the lesson review element. This procedure provides reasonable assurance that students who pass the pretest have demonstrated the same mastery of the objectives as those students who go through the related lesson element and pass the lesson review element.

2. The test items shall be assembled in random order to diminish transfer effects among items.

3. The pass-fail standard for any pretest shall be no lower than 80 percent. Students who pass the pretest at a level below 100 percent were given instruction pertinent to the test items which they missed before being allowed to proceed to the following lesson module. In the micro system model, this meant free choice of the lesson or post-test.

4. The number of items in each pretest shall be sufficient to assure reasonable test reliability. Eight (8) test items are the suggested minimum number of questions in a given pretest.

5. Maximum use will be made of multiple-choice items. However, fill-in or constructed response test items are permitted if achievement of the relevant objectives can be tested with greater validity by these types of test items.

6. Each test item shall include an "I don't know" alternative to minimize guessing where feasible.

7. Cues, hints or suggestions shall not be employed in the context of the test items.

The logic for the pretest is shown in Figure 3. As explained previously in the micro system students are branched directly into the lesson element of the lesson module. Students who pass the pretest at the

80 percent level or above are given a choice to either take the lesson or post-test.

Lesson Element

The lesson element is the most critical component of the instructional model because of its function to impart the required skills and knowledges requisite to the achievement of training objectives. Success to this end is dependent primarily on the ability of the instructional programmer to construct effective and efficient course materials. Key to this process are the instructional strategies and techniques which can be employed within the structure of the model. Furthermore, the only limitation to the sophistication of the strategies and techniques that can be integrated in a model designed for a CAI system is the capability of the system to execute these strategies and techniques.

The fundamental instructional strategy employed in the model described is tutorial dialogue. The power of the computer to approximate the role of a live instructor is exploited to the maximum extent possible with the current CAI system. Great use is made of branching, recycling, looping and other techniques to adapt instruction to the specific individual needs of the student. Inherent to this entire process is the careful integration of information and responses frames to facilitate learning.

Instructional Sub-Element

As indicated previously each lesson element consists of a number of instructional sub-elements. Each sub-element in turn consists of a preconditioning sequence, a conditioning chain and a prover unit.

The preconditioning sequence consists of two or more information frames which serve a two-fold purpose. First, to introduce students to the subject matter presented in the conditioning chain and second, to function as part of the forward branching procedure. Figure 4 depicts the logic related to the processing of students after completion of the information frames in a preconditioning sequence. The flow chart shows that students completing the information frame are sent to the conditioning chain. Figure 5 shows the logic for a typical information frame which is

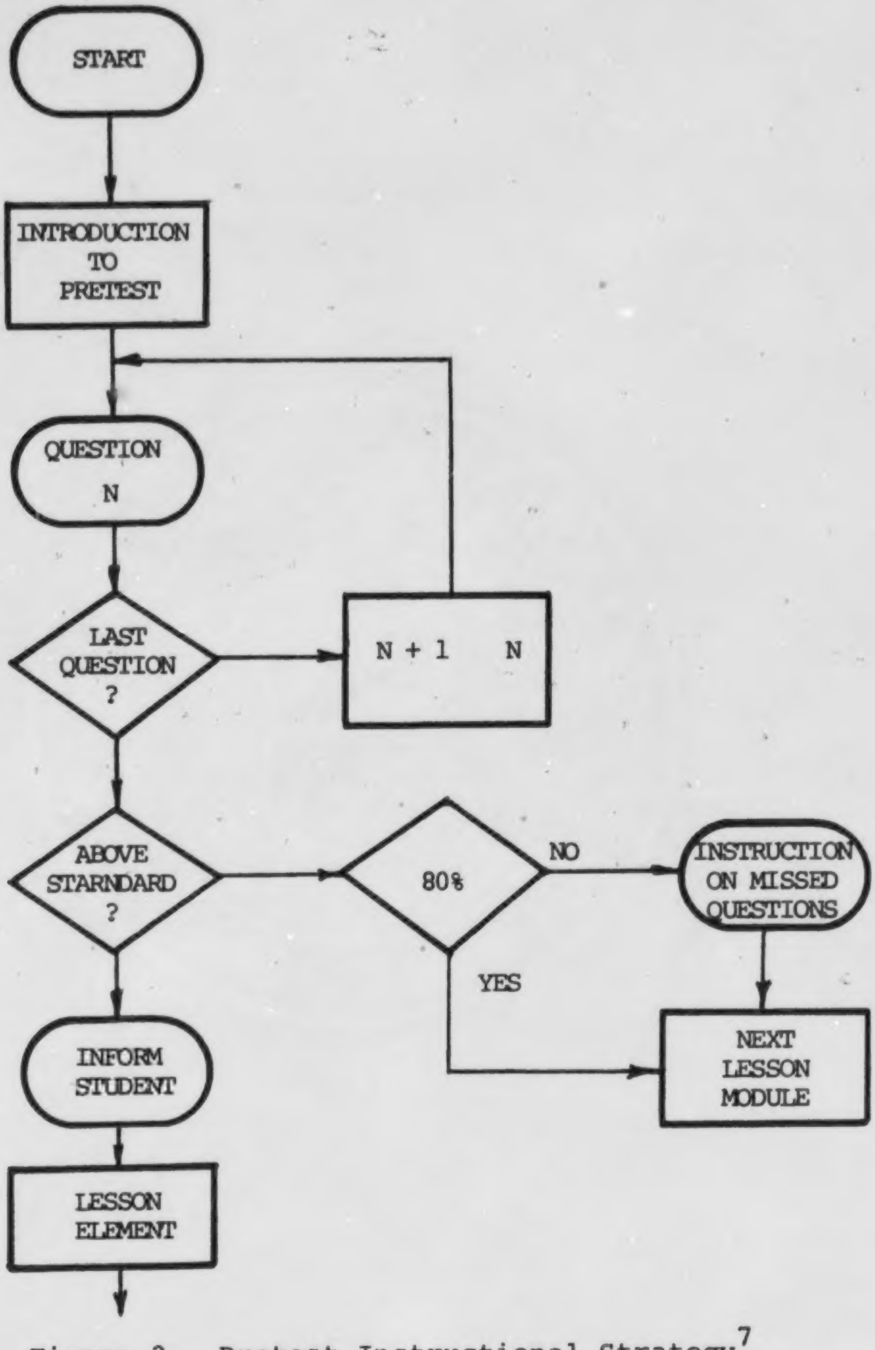
START
INTRODUCTION TO PRETEST
QUESTION N
LAST QUESTION ?
N + 1 N
ABOVE STARNDARD ?
80%
NO
YES
INSTRUCTION ON MISSED QUESTIONS
NEXT LESSON MODULE
INFORM STUDENT
LESSON ELEMENT

Figure 2. Pretest Instructional Strategy[7]

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[7] Ibid., p. 11.

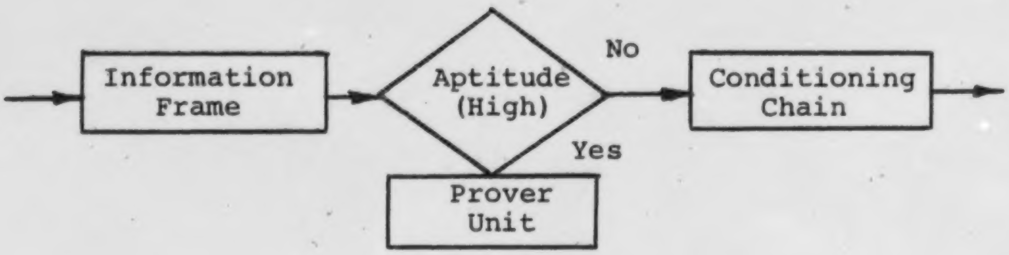

Figure 4. Preconditioning Sequence Logic

utilized in the preconditioning sequence as well as in other parts of the model. It should be noted that the student controls the length of time an information frame is displayed. Although information frames do not call for a response, they serve a vital function in providing critical information prior to a response frame and thereby provide reasonable assurance of a correct answer on the first attempt.

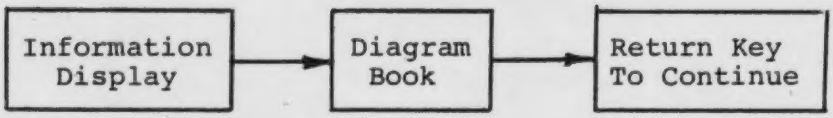

Figure 5.

The conditioning chain consists of information and response frames integrated in a sequence that enables the student to master the objective reflected in the prover unit. The information frames are similar to the ones already described. The response frames are of two types, namely, multiple choice and fill-in (constructed). For the most part multiple choice frames are used primarily because their structure permits keying remediation that is specific to anticipated wrong answers. Furthermore, it has been determined that multiple choice response frames are just as effective as constructed response frames from the instructional viewpoint. However, constructed response frames are used whenever the instructional programmer feels their use is merited. Teaching a new term and then having the student recall rather than select the term is an example of the use of constructed response frame.[8]

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[8] Ibid.

The instructor's primary role is to give individual attention to students who experience difficulty in responding correctly. Although not shown in the response frame logic, a student can voluntarily call for instructor help. At the present time, any extensive remediation that may be required is usually provided by the instructor. Eventually, however, as the problem of poor learners is better defined, remediation will be furnished primarily through expansion of the branching currently employed. It must be emphasized that the instructor normally provides response frame remediation only if a student fails to answer correctly within the limits of established criteria. In the micro system, students must ask the instructor for help.

> It should be noted that in addition to providing instructor help when needed, the response frame logic is attentive to other instructional contingencies. For example, numerical values, which are entered as constructed responses, are checked to see if they are within the acceptable limits for a correct response; hints are given if requested; critical wrong responses receive immediate remediation and unknown responses are identified and suitable messages presented to the student regarding these. Furthermore, correct answers receive confirmation before the student is allowed to proceed to the next frame. It should be noted that the student must respond correctly before he/she is allowed to continue to the next increment of instruction.
>
> The prover unit consists of one or more response frames. For the most part the instructional contingencies addressed in the logic for this type of response frame are the same as those found in a conditioning chain response frame. However, two additional special considerations are included in the prover frame logic. First, the students who give a wrong answer to a prover frame on the first try are cycled back to the beginning

of the conditioning chain. Second, an "I don't know" alternative was included where necessary to keep guessing at a minimum level. This latter contingency was provided because of the critical nature of the prover frame in terms of testing for mastery of an objective. Including an "I don't know" alternative gives the student an option to receive additional information to increase his confidence in being able to respond correctly. Students who select the "I don't know" option on the first try are sent directly to the start of the conditioning chain. As in the case of a response frame in the conditioning chain the student must respond correctly to a prover frame before being allowed to continue his/her instruction.

Lesson Review Element (Post-Test)

The lesson review element of each lesson module functions as a strategic checkpoint to determine if the objectives of the lesson module have been achieved and, therefore, if the student is ready for the next increment of instruction. The crucial nature of the lesson review makes it imperative to provide effective remediation for those students whose performance does not measure up to expected standards. This is accomplished by providing summaries and explanations for each test item prior to the lesson review. These are made available to the students for all test items they fail to answer correctly. In addition, provision is made for recycling students through the entire lesson. However, this option is exercised primarily at the discretion of the instructor.

The guidelines for the construction of the test items in the lesson review are the same as those established for the pretest items. As a result, the instructional programmer must pursue extreme care in making sure of the compatibility of pretest and lesson review test items. This can be determined most effectively through item analysis procedures.

Students who pass the lesson review at the 80 percent level are advanced to the next lesson module if they choose. Students who pass the lesson review at less than 80 percent are recycled through the lesson module or given specific remediation on the questions that were answered incorrectly. In the military model, greater options were available and more choices of handling variations were achieved. The execution of the recycling option depends on the degree of failure and an evaluation by the instructor.

> Although a rare occurrence, it is possible for a student to fail the lesson review a second time even after he has been recycled or given intensive remediation. In these rare cases the instructor personally provides the necessary remediation to correct the noted deficiencies and thereby makes sure that the student is ready to continue.[9]

Future Considerations

The instructional model described here was an early limited step in the exploitation of the potential of computer assisted instruction as a teaching method. Even so, judging from the results attained with its application to basic electronics subject matter, the model has demonstrated practical utility with a high degree of success. However, a basic question which must be addressed in this evolution is the degree of complexity that can be justified from the instructional and economical viewpoints. Is it really necessary that the ideal model address every conceivable variable, factor, or contingency internal to or associated with the learning process? Better, perhaps, is the identification of the critical elements and to use these as the principle determinants for the instructional strategies designed into the model? This approach, because of its practical orientation, should promote the development of models that can be implemented and maintained economically.

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[9] Ibid.

There were several aspects of the proposed instructional model which warranted further development. For example, the model generally specified a single mainstream of instruction. This presented some problems in best meeting the needs particularly of high and low aptitude students. Therefore, serious consideration should be given to a more flexible model with the capability to determine learning paths based on real time decisions through on-line analysis of performance and other data. This advance should make learning more adaptive to individual aptitudes and needs. Another area that appeared to need improvement involved the remediation provided students who experienced difficulty. Greater stress in the use of the computer in the diagnostic mode should have made it possible to provide remediation that was sensitive not only to the identify of the difficulty but to the origin of the difficulty as well. Also, greater use of the computer as a manager of instruction should be considered in the next version of the model. As pointed out earlier, an initial step in this direction could be applied in the area of computer manager for practical exercises. In addition, major testing such as the phase written and performance tests should be administered in either the CAI or CMI (computer managed instruction) modes. The powerful diagnostic capability of the computer can be incorporated to assess student achievement on these tests to determine the specific additional instruction needed to bolster weak areas of performance. Finally, the next version of the model should be made more sensitive to response latency than was shown. In future models, it may be possible to include response latencies as a factor in determining the instructional paths made available to students. Certainly, application in an ongoing program is the most expeditious way for determining if improvements are required. Also, as the micro computer becomes more powerful, continual revision of software should be made to incorporate these changes in the programs.

Readability Level of Programs

To insure the usefulness of the instructional scripts of CAI interactive system, and to be sure that the readability of the scripts were within the reading level of the students, a readability test was administered on the scripts written. The test given was the "Fog Index." The level sought for the programs was not to exceed the tenth grade level. In cases where sample examination showed the difficulty to beyond the tenth grade level, the scripts were revised to lower the reading difficulty.

It was assumed that students who were pursuing an A.B. or B.S. degree in college could read at the tenth grade level. Also, reading experts have explained that materials written at the twelfth grade level have a "danger line" in them regarding efficient communication for the average person. This was due tc vocabulary and terminology limitations of the average person toward technical data.

To find the Fog Index for a passage of script take these three simple steps.

1. Jot down the number of words in successive sentences. If the piece is long, take several samples of 100 words, spaced evenly throughout it. If sampling is done, stop the sentence count with the sentence which ends nearest the 100 word total. Divide the total number of words in the passage by the number of sentences. This gives the average sentence length of the passage.
2. Count the number of words of three syllables or more per 100 words. Do not count words that are:
    a. Proper names;
    b. Combinations of simple words like "bookkeeper" or "manpower"; and
    c. verb forms made three syllables by adding "ed" or "es" like "created" or "trespasses." This will give you the percentage of hard words in the passage.

3. To get the Fog Index, total the two factors just counted and multiply by .4.

The number obtained here will be the grade level of the written materials. Eight will indicate the eighth grade, 10.6 will be the second half of the sophomore level in high school, etc.

There are some considerations that should be noted here before showing a sample of the scripts which were tested. First of all, it is assumed that new words or vocabulary are introduced and defined prior to the lesson. If they are incorporated into the lesson, the difficulty level will possibly increase by as much as one grade. Second, the Fog Index used was suggested for technical writing, as any repeat words of three syllables or more are counted only once. The second time they are used, they would not be counted as new information. Third, scripts which are divided according to the number of characters per line must be modified to avoid the risk of presenting information and confusing syntax.

Below is a sample script which has been counted, modified and calculated in two ways. One way was by counting all three-syllable words, the other was by counting only new three-syllable words one time.

Sample Fog Index

MATERIALS having many free ELECTRONS are USUALLY METALLIC and known as CONDUCTORS because they conduct ELECTRICITY. MATERIALS having few free ELECTRONS are USUALLY NON-METALLIC and are known as NON-CONDUCTORS because they INSULATE against ELECTRICITY. Your neighborhood ELECTRIC power COMPANY DISTRIBUTES most of the ELECTRICITY it GENERATES to you using copper and ALUMINUM wires. Metal wires are used because they conduct ELECTRICITY better and more cheaply than any other way we know today. Copper and ALUMINUM are two of a long list of metals which are good CONDUCTORS. Good CONDUCTORS have one thing in common. They all have many free ELECTRONS.

Total number of words = 100   100÷7 = 14.29

Total number of sentences = 7

Number of three or more syllable words = 22	Number of three or more syllable words (used more than once but counted only once) = 14
$\begin{array}{r} 14.0 \\ +\ \underline{22.0} \\ 36.0 \\ \times\ \underline{\quad .4} \\ 14.4 \end{array}$ Fog Index	$\begin{array}{r} 14.0 \\ +\ \underline{14.0} \\ 28.0 \\ \times\ \underline{\quad .4} \\ 11.2 \end{array}$ Fog Index

Another Illustration Further Into the Lesson

The ILLUSTRATION in your booklet, Figure 64, shows the most common form of each kind of RESISTOR. 1. The carbon RESISTOR TERMINATES in pigtails. 2. The wire-wound RESISTOR TERMINATES in SOLDERING bugs. Notice that the fixed carbon-graphite COMPOSITION RESISTOR is a small CYLINDER with color coded bands near one end? A. Carbon graphite B. Wire wound. Color codes are used on carbon RESISTORS because printed digits on small CYLINDERS are more EXPENSIVE. Wire wound RESISTORS are larger in DIAMETER.

Total number of words = 99   99÷8 = 12.38

Total number of sentences = 8

Number of three or more syllable words = 18	Number of three or more syllable words (used more than once but counted only once) = 8
$$\begin{array}{rr} & 12.0 \\ + & \underline{18.0} \\ & 30.0 \\ \times & \underline{.4} \\ & 12.0 \end{array}$$ Fog Index	$$\begin{array}{rr} & 12.0 \\ + & \underline{8.0} \\ & 20.0 \\ \times & \underline{.4} \\ & 8.0 \end{array}$$ Fog Index

As you can see from the sample evaluation, one graded out at 8.0, the other at 11.2. The one which graded 11.2 was rewritten and simplified without changing the technical accuracy of the material. Shorter sentences were used and simpler terms utilized in the explanations. Caution should be observed in using this "yardstick." Apply it after you write, not before, as good writing must be alive; don't kill it with the system.[10]

A sample CAI/CMI program script incorporating these guidelines is shown in Appendix C of the study. It includes the management data required for the program as well as the listing of the BASIC indirect statements essential to run it on a micro computer system.

Data Collection

The second phase of the study was to look at the effectiveness of the microprocessor system as an instructional tool and to study some of the human factors associated with using it in an actual classroom setting.

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[10] Robert Gunning, The Technique of Clear Writing, revised edition (New York: McGraw-Hill Book Co., 1968), pp. 38-40.

To obtain data about these areas, a survey instrument was developed and records kept on students who participated in the CAI sysatem. A copy of the survey instrument can be found in Appendix D of this study.

Also, to obtain more personal data about the students in the study, an interview schedule found in Appendix E, was developed and administered to all students participating. These two data sheets accompanied by the records of the lessons taken, pre-post test scores and academic characteristics of the students provided the majority of the data about the human factors involved in the study.

The following procedures and time lines were followed in collecting data for the study.

1. A four-terminal, CRT microprocessor interactive CAI system was constructed in line with the capabilities thought basic to a simple system, December 1975 to December 1976 for under $10,000. This was a separate study done by Lloyd Thompson at the University of Northern Colorado in the spring of 1977.
2. Seventy instructional programs were written by D. L. Jelden and tried out in a classroom environment by students and knowledgeable electronics personnel to check problems or revisions that had to be made. This was done from January 1976 to spring 1979.

This development included the necessary diagram books which accompany the programs.

3. Comprehensive pre-tests in electronics were administered to all students who entered the class to determine their initial level of competence in electronics. Post-tests were administered at the end of the course to evaluate the growth which had taken place during the course as a result of instruction.
4. Students were given an opportunity to participate in CAI lessons for the electronics classes offered. Each was requested to take at least five lessons per quarter (ten weeks). The actual study was started in March 1978 and continued until June 1980.
5. Records were kept on each student regarding the CAI lessons taken and the pre-post test scores obtained in those lessons. Also, students had to indicate if the CAI lesson was their initial learning experience over the topic covered or an adjunct to a preceding presentation by film, video tape, lecture, commercial text or laboratory activity.
6. The survey instruments were administered to each student at the beginning and end of the course. The results of these data were tabulated and treated in a descriptive

manner using general summative statistical techniques. High levels of significance and sophisticated statistical analysis were thought inappropriate for the data gathering techniques used. It would have generated an artificial refinement of data and possibly led to faulty conclusions. The participants in the study varied widely and their selection was not under strict control.

7. The number of students involved in the study was 201 over a 30 month period in four class offerings: IAT 180, General Electricity; IAT 281, Electro-Mechanical Equipment; IAT 480, Electronic Circuit Applications; and IAT 485, Digital/Microprocessor Basics. Data obtained from each class were combined and treated as the experimental group. No control group was used in the study.
8. Findings and conclusions of the study were general in nature and covered both the hardware of the system (limitations and characteristics) as well as the human factors obtained from the survey instruments.

CHAPTER IV

FINDINGS OF THE STUDY

Introduction

The findings of this study are actually divided into two categories. One category deals with the hardware of the system and its limitations. The other is a report of the student interactions, feelings and attitudes about the system. To begin with, the data pertinent to the microprocessor system in interactive CAI program will be presented.

Characteristics of the Microprocessor System

The microprocessor system generated for this study and typical for those commercially available operated with a total CPU memory capacity of 64 K-BYTES. The system used was an Altair 8800 with four 16 K-BYTE 100 buss memory boards. The bootstrap loader incorporated to speed up the initialization of the system took up two K-BYTES of memory and thus restricted the core size of the actual system of 62 K-BYTES. The language used was Altair Timeshare Extended Disk Basic. At the time the study was initiated, MITS Pertec (Altair manufacturer), indicated that a multi-user programming language would be available shortly for use. Several months later an operational software package was available.

The first version, Time/Share 1.1 was useful for operating the terminals and accessing instructional programs on the disk. However, it did not provide for the writing of random files to record the pre-post test scores of the students participating in the study. This had to be done by the students on a separate progress chart. Because the scores did not affect the grade given for the course, it was assumed that the scores recorded by the students were in fact indicative of their performance. Thus, one of the main advantages of implementing interactive CAI, that of record keeping, was lost. A later version, 2.0 Time/Share Disk Basic was developed which could read and write random files. Its operation was questionable, as classroom application made the system "lock-up" and support help from MITS was inadequate. Thus, the random file operation was discarded and individual pre-post test scores were recorded by students on a progress chart near the terminals.

Since that time, random read-write software packages have been identified and proven operational. The lesson to be learned here is to take cautiously the word of the manufacturer of what will be. They may tell you anything to sell you the hardware. Also, support from the manufacturer for hardware repair and software limitations/ operations is critical. In fact, service and operation support may become at least as important as hardware limitations.

Although the management capabilities were not incorporated in this preliminary study, they were designed and added to each script. The management file is included in the appendix for your convenience (see Appendix B). It was organized in the following way:

CMI LOAD -- This allows the teacher to build a record file for each class which automatically records students' pre-post test scores as they are taken.

CMI EXTD -- This allows for the extension of the class record file if new students are to be added to the class once the class begins.

CAI INTR -- This is input to the front end of each test to provide data and assign values to pre and post-test scores. It also allows only authorized class enrollees to take any lesson.

PRETEST -- This records the pre-test score and directs the student to the proper location within the program for instruction or further testing.

POSTTEST -- This records the post-test score and gives the student direction on where they should proceed at the end of the lesson; that is to recycle or go on.

CMI REPT -- This is the program that is run by the teacher to determine progress of the class and the lessons taken by each student. It reports the lessons taken and the pre-post test scores for each student alphabetically as they were placed into the system under the "CMI LOAD" program.

To facilitate this management system, two floppy disk drives are needed, one is used for instruction and program storage (disk 0) and one is used for class/student record keeping (disk 1). Records for 250 students on 25 lessons could be kept on the record file. With modification, this could probably be extended. Once the record file was made it could be used for all classes (in this case, four) and left in the system. A safety code was used in the record file to keep one student from writing on another's record. This was done by assigning a CAI student number and unknown to the student comparing it to his university student number for verification. If they did not match, the lesson was terminated without informing the student of the reason. This system seemed to work very effectively and security of "CAI numbers" did not present a problem.

The biggest disadvantage of a small microprocessor interactive CAI system was program memory. With one 300 K-BYTE disk for records, only one was left for holding the instructional programs. This meant that about four to six lessons could be stored on the disk at any one time, as the lesson size varied from 50 to 90 K-BYTES each. This severely limited access to all of the lessons in the system. However, it was partially solved by posting the lessons available per class on a day and time block so students could have an idea of what was available on the computer. For example, on Tuesday, October 8, lessons #4 through #8 would be on the computer from 8:00 a.m. until 2:00 p.m. Students wishing to take any of those lessons would have to come in at that time or make other arrangements.

This restriction did not greatly affect computer utilization but it did limit the mix of students who may wish to take a lesson at any one time. This process was further refined by making a schedule for a full quarter (ten weeks) listing days, class, time and lesson availability so students could plan ahead of time when they wished to use the computer to get information. In setting up or planning such a system, thought might be given to having laboratory assistants extend the time available by operating on a 12 to 15 hour day, utilizing the evening hours until 10:00 p.m. or so. This extended time may give better utilization per dollar invested and lower the cost per pupil figure.

Experimentation with lesson storage also determined that more lessons could be stored on the disk if they were "saved" in digital code rather than ASCII code. Savings as much as 25-40 percent were obtained by utilizing this practice. On the average, six lessons could be stored in digital code compared to four lessons in ASCII code. When this practice was followed, however, file flexibility was diminished considerably as no files could be merged if saved in the digital mode. For back up purposes, all master program files (lessons) were stored in ASCII code to facilitate editing and other manipulations.

As mentioned earlier, only 62 K-BYTES of memory were available in the CPU core. With approximately 20 K-BYTES used for extended disk basic as an operational language, this left 40,456 BYTES for terminal usage. The initialization of the system provided for allocating core size to each terminal. As such, about 10,000 BYTES could be assigned to each port (terminal) for individual student use. If each lesson was 40 K to 60 K in length, some system of "overlay" had to be set up to allow four terminal operation and access to each lesson. To accomplish this, each lesson was divided into segments or parts.

The last program line of each part had a statement which loaded and ran the next segment automatically. The operator was unaware of this separation except when a 5-10 second delay occurred within the lesson as it was being run. The terminal would display a message to the effect that "hold on, I'm getting the rest of the lesson," and then continue. This system seemed to work very well but it did limit the sophistication of the management of the lesson and the degree of branching which could be done within the system. Each segment of a lesson had to be more of less self-contained. This restriction did not greatly hamper either the programmer or the student, as each part was treated like a lesson module.

Consideration for expansion of the system centers around greater disk capacity, for example a 24 MEG hard disk and core storage. The basic system could handle up to eight ports with its existing vector interrup configuration and real time clock. If more ports were to be added to the present system, lesson segment size would have to be reduced accordingly to match the core per port capacity. Experience with this system suggested that lesson segments less than 4-5 K-BYTES in size would be impractical. This is due to a severe limitation in branching and programming restrictions given in the lesson guidelines.

From previous research findings and as a result of this study, it was recommended that CRT (cathode ray tubes) be utilized as interface ports or instructional devices. The terminals used in this study were Lear-Seigler ADM-1 CRT's (two ADM-1 and one ADM-1A). They were more sophisticated than what was actually needed, but worked very well. The display system was set up using the following criteria:

1. The screen could be set to give a 12 line or 24 line display; 12 line display was chosen to provide separation between script and increase the "readability" of the presentation.
2. The display width of the lines was 80 characters maximum. To make reading easier, a 40 character line was recommended. Also, if future applications regarding split screen operation or visual display of pictorial information was to be developed, the program would be compatible for such a system application.
3. After each frame of presentation, a clear-screen home-cursor operation was performed. This displayed the scripts from the top down and from left to right as a normal presentation. This procedure increased the speed of comprehension and presented data not unlike

traditional display devices. In this way, lines would not "jump" up from the field of view as data was being presented (as per linear presentation resulting from scrolling).

Having the same terminals (ADM-1's) allowed all clear screen commands to be operational without program changes.

These techniques worked very well and were received with no specific criticism from students.

The last criteria considered for the CRT was the "baud rate" or speed of presentation. The terminals used allowed a variations from 150 to 9600 baud. Two terminals were set at 9600 and one was set at 1200. After several confrontations, students indicated that the 9600 rate did not frighten them and preferred to use it. The 1200 baud rate was primarily used for editing programs. This speed provided slower reflex time in starting and stopping the lesson. For strict lesson presentation, experienced operators complained that they felt the system "held them up." This was not a major point of concern, however, based on informal student comments.

The fourth terminal used in the system was a Decwriter II Printer/Terminal. Its main function was one of providing hard copy print-outs of lessons and laboratory calculations. It was not used with any great enthusiasm by students because of its restricted speed

(300 baud). In most cases, students after experiencing both modes of presentation, would come back at a later time rather than take a lesson on the slower printer terminal.

From the hardware standpoint, the study showed that a multi-terminal microprocessor computer system is a feasible system for instruction and that management as well as instructional modes of operation can be obtained with a reasonable financial investment. With computer technology continually improving, it should be of even greater importance in the near future as the economic gains will continue to make micro CAI more sophisticated and powerful. The advent of small hard disk storage and extended address microprocessors make the educational applications ever more appealing.

Summary of Hardware Data

Based on developmental data and actual classroom experience with the Altair system, the following guidelines are given to those who would contemplate the purchase of a microsystem for educational purposes:

1. In selecting a micro computer, the hardware (system) supplier should be readily available for maintenance and service of whatever system is purchased. Those manufacturers which provide extensive information to the operator when asked, should be given strong

consideration. Some manufacturers are reluctant to provide much technical information about their system. They should not be given first priority.

Also, only those manufacturers who have a strong and reliable reputation should be considered. If a supplier goes out of business as Altair did during the study, no support exists.

2. The capacity of your system should be at least 64 K-BYTES or able to address at least that much data. Some systems are expandable and can thus provide additional memory. If Time/Share operation is considered, self-contained or interfaced, the larger the system capacity the better. Research has shown that self-contained Time/Share is questionable at best with a system of less than 64 K-BYTES of core memory.

3. Standardization with other systems in existence (disk drives, formatting, language, and interfacing) should be evaluated. Extensive program revisions, copying disks and adding additional boards can create problems if either the software or hardware should want to be changed. For example,

100 pin buss systems make it possible to upgrade memory boards. The interchangeability of disks from system to system contributes to the exchange of programs and software among users. A unique system imposes limitations on one's alternatives.

4. If Time/Share is important, CRT's should be standard RS-232C compatible. Also, if special clear screen commands are employed in framing information, the terminals should have a similar ASCII code for "clear screen and home cursor." Even different models of a particular system may be uncompatible. For example, an ADM-1 and an ADM-3 do not clear screen with the same character code. The ADM-1 uses (27) and the ADM-3 uses (26). In effect, this would require minor program modifications to be used in a classroom setting.

5. Maintenance funds should be provided for upkeep and replacement parts. From December 2, 1976, until July 1, 1980, a total of $1483.65 was spent to maintain or upgrade the system. This cost was for 4029 plus hours of operation. Roughly computing, the cost of maintenance was approximately $500.00 per year on a $10,000 investment or about five percent of

its initial cost. If improvements are to be incorporated into the system as technology changes, 10 percent of the cost of the equipment is not out of line. Also the life expectancy of the computer was anticipated to be about 5000 hours.

The cost of system maintenance broke down in the following manner (3 1/2 year period):

Alignment of Disk Drives (every 1000 hours)	$ 200.00
Terminal Repair/Maintenance	$ 280.00
New Memory Boards (CPU)	$1003.65
Total	$1483.65

If considerable programming is to be done, the cost of 8" floppy disketts will run approximately $5.50 per disk. The 70 lessons and their back-up copies included a total of 54 disks. The cost for these disks alone came to around $297.00. For a small program, this is a factor to compute in the operation and maintenance budget. This additional cost was not computed in the previous budget record of $1483.65.

6. Because the system was designed for Outreach educational purposes in the region, the increased wear and tear of moving the units at least once a week in the trunk of a car

did raise the cost of maintenance. In fact, the disks were the most fragile of the whole system. Their reliability was altered considerably when they were moved often. A permanent installation may encounter a lower need for repetitive disk alignments. Also, the quality of the disk drives will have much input on how rugged the system is. The Altair drives were a little suspect after 500 to 1000 hours of use. Disk reliability should be completely evaluated.

7. The operating system, in addition to the disk reliability, created some problems. A dependable system must have an operating system that is fast, dependable and flexible. The re-configuration routine in the Altair was such that as more disks were added or ports addressed, the reliability of the system went down. For example, if four users tried to save programs on the disks at intermittent times, many I/0 errors were made. At times, the system would even lock up and re-initializing the entire system was called for. To this end, any student who was taking a lesson or who was programming, lost all of their data. Many hard feelings were generated over

this problem. Therefore, any MP/M or reliable Time/Share operating system should be proven before the CAI program is adopted.

Human Considerations of CAI

Introduction -

For the period of the study, the students in the four electronics classes were asked to take at least five CAI lessons during the course in which they were enrolled. It was felt that five different lessons scattered over a ten week period would familiarize the students with the operation of the terminal, the layout of the lessons and the characteristics of the CAI system in general. At the completion of the course, an information form was administered (see Appendix D) to obtain data on their personal feelings and attitudes toward CAI. The following data is a compilation of that information.

Demographic Data -

As shown in table 1, the class ratio of boys and girls was heavily weighted toward the boys. Of those twenty girls who did take the class, the table shows that half were in their senior year of studies. Not one freshman girl enrolled in any of the electronics offering during the time of the study. Also, it should be noted that no girl graduate students were enrolled in any electronics classes for that period.

With more girls selecting industrial arts as a major, this mix is anticipated to change and the representation by class between boy-girl should be somewhat consistent in the future.

TABLE 1

COURSE ENROLLMENTS BY
CLASS AND SEX

Classes	Boys	Girls	Total
Freshman	32	0	32
Sophmore	34	4	38
Junior	42	6	48
Senior	60	10	70
Graduate	13	0	13
Total	181	20	201

Table 2 shows a breakout of the course make-up by class level.

TABLE 2

ENROLLMENTS BY
COURSE AND CLASS LEVEL

Course	FR	SO	JR	SR	GR	Total
IAT 180	27	32	27	24	3	113
IAT 281	3	6	21	39	7	76
IAT 485	2	0	0	7	3	12
	32	38	48	70	13	201

Notice that the electronics circuits class, IAT 480 was not offered during the study although it was included in the proposal. It just so happened that in the sequence of course offerings, the IAT 480 class was alternated with IAT 485 and was, by chance, missed.

As explained in table 2, the largest enrollment is in IAT 180, general electricity. As both an elective for general education and a requirement for all industrial arts and technology majors, it had the widest representation of majors. Table 3 shows the number of students represented in the study identified by major. No attempt was made to further break down this data into class level or course offering. The reason major was chosen was to show that the data obtained for the study did not represent only industrial arts and technology majors. Although they were clearly the majority (140 out of 201) the total population represented 18 major programs and a number of uncommitted students.

A cross check was made by the computer and manually to see if significant variations in the data existed when compared by major. None did, so the data was treated as a total block. Also, it was felt that the numbers of students in most majors was so small, no valid conclusions could be drawn from the data anyway.

TABLE3

STUDY PARTICIPANTS BY MAJOR

Major	Number	% of Total
Industrial Arts and Technology	140	69.5
Business		
No Major	12	6.0
Theater	8	1.0
Audiology	5	2.5
Music	4	2.0
Accounting	3	1.5
Elementary Education	3	1.5
Arts and Science	2	1.0
Chemistry	2	1.0
Curriculum and Instruction	2	1.0
HPER	2	1.0
Communications	1	.5
Data Processing	1	.5
Fine Arts	1	.5
Journalism	1	.5
Mathematics	1	.5
Psychology	1	.5
Zoology	1	.5
		100.0%

Student CAI Background -

For general information, the students were asked if they had any previous experience in terminal or computer usage. Table 4 breaks this data down by class. Notice that the higher the class level, the greater was their previous contact with the computer. Also, it was possible for a student to enroll in IAT 180 with no experience and then in another quarter to enroll in IAT 281 and indicate that he/she had previous experience. For the purpose of this study, it would have been interesting to study only those students who had this confrontation as their first experience with CAI. This was not done and it is assumed that the previous experiences would not greatly affect the results of this study, as attitudes, positive or negative, could have changed during this classroom confrontation.

It was interesting to note that half of the students enrolled in the electronics program had some previous experience with a computer terminal or system. This would dispel the myth that CAI in some form is a unique expectation for college students. It may very will be a common experience now and will surely be in the near future as computers become more common in the classroom.

TABLE 4

PREVIOUS COMPUTER EXPERIENCE
BY CLASS

Classes	Yes	%	No	%
Freshman	12	37.5	20	62.5
Sophmore	14	36.8	24	63.2
Junior	26	54.2	22	45.8
Senior	42	60.0	28	40.0
Graduate	7	53.8	6	46.2
Total	101	50.2%	100	49.8%

Computer Utilization -

In this study, the computer was used as an adjunct to the other modes of instruction available in the classroom. Because of the labs unique multi-media environment, the students had a choice of the sequence and types of media used. Video tapes, 16 mm films, standard programmed books, traditional texts, 35 mm tape-slides and teacher lectures were available to the students as well as the programmed computer lessons. With this option of free choice, the sequence and way in which the computer was used was of interest. Table 5 shows the utilization. We simply asked the student if they used the computer before (initial learning experience) or after (supplemental application) the other sources.

TABLE 6

ATTITUDE TOWARD SYSTEM OPERATION

(Were you apprehensive about its use?)

Class	Prior To Instruction				After Instruction			
	Yes	%	No	%	Yes	%	No	%
Freshman	20	62.5	12	37.5	8	25.0	23	71.9
Sophomore	22	57.9	16	42	3	7.9	34	89.5
Junior	22	45.8	26	54.2	3	6.3	44	91.7
Senior	40	57.1	29	41.4	10	14.3	59	84.3
Graduate	7	53.8	6	46.2	0	0.0	13	100.0
Totals	111	55.2	89	44.3	24	11.9	173	86.1
No Response	1	.5%			4	2.0%		

al operation.

For some reason the freshman and seniors had the most apprehension after instruction although the number did not appear significant. It appears that apprehension about system and terminal drops considerably after limited use. This was logical and expected.

Lesson Length -

In order to obtain general information about lesson length and the time it took to take a test and/or a lesson, students were asked to estimate how long it took them to take a pre or post test and also the lesson. It was hoped that no single lesson or program time would exceed 45 minutes, as this time would fit well within a 50 minute class period.

Also, if remediation of instruction was done rather extensively by the lesson in the computer, to be educationally sound, it should not be split over two class periods. Table 7 shows the average time spent by each class level on the lessons they took in the system.

TABLE 7

AVERAGE LESSON LENGTH BY TIME IN MINUTES

Class	0-15	15-30	30-45	45-60	60 Plus
Fresnman	9	12	7	4	0
Sophomore	1	16	9	6	1
Junior	1	23	14	3	4
Senior	5	20	24	13	2
Graduate	1	3	6	0	0
Totals	17	74	60	26	7
Totals %	8.5	36.8	29.9	12.9	3.5
No Response	17	8.5%			

As indicated by table 7, the majority of students, 88.1% did finish the lessons in under 60 minutes, with about 76% finishing under the 45 minute limit. Therefore, the goal of 50 minutes was assumed to have been achieved and the lessons length validated in actual classroom situations.

Although one-fourth of the students did take over 45 minutes to complete the average lesson, time alone was not a critical factor in learning. The course structure for all of the electronic offerings was two successive periods. This organization in fact had no affect on lesson length in the study. Time was only to give the author and user a general estimation of how long the average lesson would run. Actual time is based specifically on each individual students input and response accuracy.

Rate of Terminal Display -

Because data was not available on the rate of display for CRT applications in a CAI setting, three display speeds were established for the time of the experiment. They were 9600, 1200, and 300 BAUD. BAUD is a term used to relate the characters per/second display generated by a computer. To simply explain it, a 1200 BAUD presentation equates to approximately 450 words per minute, which is slightly better than an average person's reading speed. A fast reader would have to wait on a 300 BAUD display to read information. The rate of display would thus effect the speed at which a student could go through a lesson.

Table 8 shows the students reaction to a question relating to the suitable rate of display of the lesson material.

Based on the information obtained from the students, it was very apparent that the preferred BAUD rate for CRT presentation was 9600 BAUD. Also, because of printer limits, the hard copy print-out did not rate very high. This would lead one to believe that for teaching purposes, CRT's are preferred. If a hard copy is needed, then a printer is required. Most micro systems have a limit of 300 BAUD. Print-

TABLE 8

PREFERRED RATE OF DISPLAY FOR LESSON AT 9600

Class	1200 BAUD (too slow)		9600 (about right)		9600 (too fast)	
Freshman	2	6.3%	30	93.8%	0	0.0%
Sophomore	1	2.6%	37	97.4%	0	0.0%
Junior	2	4.2%	45	93.8%	1	2.1%
Senior	2	2.9%	64	91.4%	1	1.4%
Graduate	0	0.0%	12	92.3%	1	7.7%
Totals	7	3.5%	188	93.5%	3	1.5%
No Response	3	1.5%				

ers are not as efficient as CRT's for transmitting information in an educational setting. Therefore for a small four terminal system, no more than one printer is recommended.

Utilization of Diagram Books -

With million dollar systems, CAI has the ability to generate and manage many sophisticated visual displays. With a micro system, such sophistication is not possible. To incorporate some sort of visual capability, a diagram book was developed to accompany the verbal instructions of the lesson. These diagrams were used by referring in the lesson to a specific drawing in the book and technique, a question was asked regarding their adequacy. Table 9 lists the responses of the students by class.

Based on the overwhelming response, 94% of those using the book said it did the job. This shows that such utilization is very servicable for CAI micro systems.

TABLE 9

ADEQUACY OF THE DIAGRAM BOOK

Class	Yes	%	No	%
Freshman	31	96.9	1	3.1
Sophomore	36	94.7	1	2.6
Junior	45	93.8	1	2.1
Senior	64	91.4	4	5.7
Graduate	13	100.0	0	0.0
Totals	189	94.0	7	3.5
No Response	5	2.5%		

Care should be taken however, to select the simplest and most representative drawing possible to explain the principle or concept under study.

Pre Post Test Validity/Difficulty -

In order to improve the quality of the interactive instructional lessons, the students were asked to indicate if the test items in the programs covered the material in the objectives, particularly, those items on the post-test over the basic elements of instruction within the lesson, It was thought that doubts about what the items on the post-test covered would help identify either poor instruction in the lesson or poor test questions over the instruction.

In addition, the students were asked to judge the difficulty of the test items on the post-test. This evaluation should also help identify questionable items on the post-test or within the lesson. In general, the reason for the inclusion of these two items on the form was to upgrade the quality of the instructional lesson and the post-test. Tables 10 and 11 indicate the results of post-test items for the programs. The data shows the tests were very adequate.

TABLE 10

VALIDITY OF POST-TEST ITEMS

Class	Yes	%	No	%
Freshman	31	96.9	0	0.0
Sophomore	35	92.1	1	2.6
Junior	45	93.8	0	0.0
Senior	68	97.1	1	1.4
Graduate	13	100.0	0	0.0
Totals	192	95.5	2	1.0
No Response	7	3.5%		

Terminal Usage -

Because of the physical restruction of a microcomputer system and the number of terminals which can be interfaced to it for instructional purposes, students were asked to indicate if this was a major problem in the class. Each course offering during the study had different size enrollments. An attempt was made to see if, regardless of enrollment, a problem existed. Class enrollment varied from 12 (IAT 485, SP, 1980) to 30 (IAT 180, F, 1979). Very simply, the question was asked, were the terminals available when you

TABLE 11

DIFFICULTY OF POST-TEST ITEMS

Class	Within Reason		Too Difficult	
Freshman	31	96.9	1	3.1
Sophomore	36	94.7	0	0.0
Junior	44	91.7	1	2.1
Senior	63	90.0	6	8.6
Graduate	13	100.0	0	0.0
Totals	187	93.0%	8	4.0%
No Response	6	3.0%		

wanted to take a lesson? The information obtained by that question is shown in table 12. Notice that over three-fourths of the students responding said that the terminals were available when needed. Further investigation by course showed that the biggest problem did in fact occur in the classes with the largest enrollment. The important point to remember here is, that four CRT's can service very nicely, 20 students in a multi-media environment. A ratio of one terminal for five students met the needs for this experiment. If greater dependency on CAI is encouraged, then more terminals are required.

As indicated by the table, some students, about one-fourth, did have trouble using the terminal when they wanted to. Instructor observations found that several terminals were unused for up to an hour on occasion. This condition,

TABLE 12

TERMINAL AVAILABILITY

Class	Yes	%	No	%
Freshman	25	78.1	5	15.6
Sophomore	28	73.7	7	18.4
Junior	35	72.9	9	18.8
Senior	49	70.0	18	25.7
Graduate	9	69.2	4	30.8
Totals	146	72.6	43	21.4
No Response	12	6.0%		

students who say they can't get a terminal and time periods when terminal are not being used during class time, indicates that better utilization might be generated by a more formalized or scheduled basis rather than on an open arrangement. The larger the class, the more structured you may have to become to get maximum use from the system.

Effectiveness of CAI Materials -

The unique environment in the electronics lab, one of individualized instruction in a multi-media context, provided some interesting comparisons between the CAI programs and other instructional media. These other media included 16 mm films, ½ video tapes, 35 mm tape-slide presentations, programmed text books, traditional texts and teacher lecture demonstrations. Previous research has indicated that all of these media are effective and efficient systems of instruction. An attempt was made in the study to ask students to compare the CAI lessons to these other modes of instruction. Further, we asked if the CAI materials were as good as or better than other media when it came to remembering information for testing purposes or applying information problem to solving situations.

Table 13 shows what the student thought about the usefulness or help they received from the CAI materials as compared to the other media available.

TABLE 13

COMPUTER USEFULNESS VS. OTHER MEDIA

Class	Good Help		Preferred Other Media	
Freshman	21	65.6	11	34.4
Sophomore	34	89.5	2	5.3
Junior	39	81.3	7	14.6
Senior	46	65.7	21	30.0
Graduate	9	69.2	4	30.8
Totals	149	74.1%	45	22.4%
No Response	7	3.5%		

As can be seen from the responses in table 13, not all students wanted to use the CAI system and some felt that other media, for them, was more effective in learning the materials.

Table 14, shows how students judged the CAI system for retention of information compared to other mdeia sources.

TABLE 14

CAI VS. RETENTION OF INFORMATION

Class	Better		As Good As		Poorer	
Freshman	12	37.5	18	56.3	2	6.3
Sophomore	19	50.0	15	39.5	2	5.3
Junior	21	43.8	24	50.0	1	2.1
Senior	23	32.9	37	52.9	9	12.9
Graduate	3	23.1	10	76.9	0	0.0
Totals	78	38.8%	104	51.7%	14	7.0%
No Response	5	2.5%				

Based on the information in table 14, over one-third of the students said CAI was a better system of learning when addressed to retention of information. The psychologists tell us that people remember longer those things which involve the most sensory inputs. To read and respond to a CAI lesson should improve ones retention when compared to a more passive instruction system, like films or video tapes. The more sophisticated the system, the more variety and sensory inputs could be utilized by the CAI system.

Terminal Restrictions -

Several students informally suggested that the CRT's did in fact, bother their eyes. One student reacted so violently to the CRT display that nausea resulted. To overcome this problem, the student used the printer instead of the CRT to take the lessons. To determine if this problem was a major concern or only the exception, students were asked to answer the question, "Did the CRT terminals bother your eyes or physically affect you in any way?". Table 15 shows the results of that question.

TABLE 15

EYE FATIGUE FOR CAI OPERATION

Class	Yes	%	No	%
Freshman	4	12.5	28	87.5
Sophomore	5	13.2	32	84.2
Junior	12	25.0	34	70.8
Senior	19	27.1	49	70.0
Graduate	2	15.4	11	84.6
Totals	42	20.9	154	76.6
No Reponse	5	2.5%		

This data indicates that the teacher must be aware that all students may not be able to use CRT display terminals and also that extended periods of time on the terminals, one hour or so, may be a factor in teaching effectiveness of CAI. Over one-fifth of the students in the study did complain of some physical discomfort from using the CRT.

Lesson Retrieval From Memory -

A big disadvantage of a micro system is the ability to run a multi-terminal time share operation and have sufficient memory space for each terminal's data in the central processing unit (CPU). To overcome this problem, all CAI lessons were written in blocks or modules and stored on 8" floppy disks for retrieval when needed. This technique was called 'overlaying' and was used quite successfully in the study. Most lessons were written in five to eight modules and consisted of about 10.5 k-bytes of data.

As the program was being executed, the operator would be told from time to time to hold on for a second as the new block or module of data was being read from the disk. This 'loading delay' took about five to eight seconds, depending on the module size. The students were asked to indicate if this minor delay bothered them in the process of lesson operation. The results are recorded in table 16.

TABLE 16

WAS PROGRAM DELAY A PROBLEM?

Class	Yes	%	No	%
Freshman	4	12.5	28	87.5
Sophomore	2	5.3	34	89.5
Junior	5	10.4	41	85.4
Senior	5	7.1	62	88.6
Graduate	0	0.0	12	92.3
Totals	16	8.0	177	88.1
No Response	6	3.0%		

As indicated by the data in table 16, over 88% of the students said the delay was not a problem and that instruction could be effective using the overlay technique. The major complaint of the disk retrieval system was the number of I/O and file-link errors that occurred as a lesson was being taken. In certain instances, the reliability of floppy disk retrieval was very bad. This was a hardware problem and could be overcome by proper disk alignment and system dependability. On the Altair system used in this study, the reliability of disk operation was below that which was anticipated prior to the study. The undependable operation of getting data to and from the disk reliability was the weakest link in the Altair system.

Program Readability -

Because the materials generated for each lesson were new, the students were asked to evaluate, in their judgment, the readability of the instructional programs. Although the "fog index" of readability was applied at random to the written lessons, the readability of the programs encompassed more than just difficulty level. As such, each student was requested to determine the ease with which each lesson was read and their ability to comprehend what was written. Table 17 summarizes the results of their feelings about the readability of the CAI lessons.

The overwhelming response to the question was that the terminology used in the script was easily understood and well within the reading level of most college students. Only three students indicated they had some reading problems. Several of those were foreign students who might be expected to have reading problems in any program or verbal media.

TABLE 17

READABILITY AND LESSON TERMINOLOGY

Class	Easily Understood		Reading Problems	
Freshman	32	100.0	0	0.0
Sophomore	37	97.4	0	0.0
Junior	45	93.8	1	2.1
Senior	66	94.3	2	2.9
Graduate	13	100.0	0	0.0
Totals	193	96.0%	3	1.5%
No Response	5	2.5%		

Skill Development -

Several of the instructional lessons were specifically designed to teach skills in using measuring instruments The operation of the voltmeter and ammeter were several examples. To incorporate skill development in the program, dynamic demonstration boards were designed with actual components mounted on them. The computer lesson presented information, gave directions on equipment operation and then asked questions on the values of voltage and current which was measured on the board. In order to continue the lesson, a correct measurement had to be made and the data inserted into the computer for response.

To determine the attitudes of students toward learning skills in this manner, as opposed to the teacher - lecture/demonstration, students completing the lesson were asked their opinion about the ability of a computer to teach equipment operation. Table 18 gives the information obtained from the respondents about this activity.

TABLE 18

ABILITY OF THE COMPUTER TO TEACH SKILLS

Class	Yes	%	No	%
Freshman	15	46.9	16	50.0
Sophomore	25	65.8	12	31.6
Junior	28	58.3	16	33.3
Senior	34	48.6	31	44.3
Graduate	5	38.5	8	61.5
Totals	107	53.2	83	41.3
No Response	11	5.5%		

Based on this information, a little over half of the students agreed; a fairly large group, 41.3%, were not convinced that this was a practical or effective way to teach meter operation. Because of the more or less even split between the responses, no major conclusions can be drawn and further research on this problem needs to be done.

CAI vs Test Grades -

Due to the nature of CAI, the use of multiple choice test questions in instructional programs and on objective final course examinations, appears to reduce the fear of testing apparent in most students. To look at the attitudes of students toward objective final exams in the program, they were asked if they felt the CAI pre-post tests allowed them to earn better grades on the course tests. The information in

TABLE 19

RELATIONSHIP OF CAI EXAMS TO FINAL EXAMS

Class	Yes	%	No	%
Freshman	28	87.5	3	9.4
Sophomore	31	81.6	4	10.5
Junior	38	79.2	6	12.5
Senior	52	74.3	13	18.6
Graduate	11	84.6	2	15.4
Totals	160	79.6	28	13.9
No Response	13	6.5%		

Table 19 addresses that question.

Although there was no direct item relationship between the test items on the final exams and the CAI instructional pre-post tests, almost 80% of the students did feel that the CAI experience did allow them to do better on the course final objective exam. It should be pointed out, that the course final exams were generated by the computer on a random basis from a test data file of 9252 questions. The validity of the computer-generated test items against the objectives and topics of the course were established when the test data file was made. If duplicate questions on both tests existed, it was by chance and not predetermined by the instructor. The general feeling obtained in informal discussion with the students indicated that the CAI tests were really 'practice tests' for the final exam. This opportunity allowed them to see what the course midterm and final was like and thus reduced their apprehension about the course tests. In fact, many students during the course requested that the instructor run them a "practice exam" from the computer to check their progress. This was frequently done.

In several of the classes, both teacher-made and computer-generated exams were given. In these cases, students were asked to identify their preference (if any) for either exam. The data in table 20 itemizes their preference.

TABLE 20

TYPES OF EXAMS PREFERRED

Class	Teacher Generated		Computer Generated		No Preference	
Freshman	8	25.0	8	25.0	16	50.0
Sophomore	5	13.2	14	36.8	19	50.0
Junior	11	22.9	14	29.2	23	47.9
Senior	25	35.7	19	27.1	23	32.9
Graduate	4	30.8	1	7.7	6	46.2
Totals	53	26.4%	56	27.9%	87	43.3%
No Response	5	2.5%				

Based on the answers to this question, about 50% said it made no difference who generated the test. The other half of the population were split into two groups, one-fourth said computer generated, one-fourth said teacher generated. In either case, tests could be generated by either computer or teacher and satisfy 75% of the group. If both systems are available, which they were in the study, the students determined how their exams were made. In one of the experimental classes, that is exactly what happened. The students chose which of the two test options they wanted.

The last item relating to testing in the course, related to the CAI pre-post tests. Students were asked if they would like to know which items they missed or got correct as they took their CAI tests. In a sense, this would allow them to learn from the test. The results are shown in Table 21.

TABLE 21

PRE-POST TEST FEEDBACK

Class	Yes	%	No	%	No Opinion	%
Freshman	31	96.9	0	0.0	1	3.1
Sophomore	37	97.4	0	0.0	1	2.6
Junior	41	85.4	2	4.2	5	10.4
Senior	62	88.6	0	0.0	5	7.1
Graduate	13	100.0	0	0.0	0	0.0
Totals	184	91.5	2	1.0	12	6.0
No Response	3	1.5%				

From the answers to this question, it is obvious that students want to know how they are doing as they take the CAI tests. From an educational point of view, not giving them that feedback on the pre-test until they were finished with the test might be more sound. However, a student does have a right to know which items were missed. Some sort of feedback arrangement could be programmed into the pre-test system. On a post-test basis, the same conditions could apply.

There is some doubt in the researchers mind that if a student knows how they're doing as they take a lesson, the option to terminate the test before completion would keep the student from recording their actual performance in the system. In any event, the pre-post testing elements are essential to a useful CAI system and communicate to the student and system how well the lesson materials are understood. Testing is only one form of educational accountability and is essential for learning.

Instructional Efficiency -

Several previous studies done in the area of CAI, concluded that the students could cover the same material faster using CAI. To relate the instructional programs of this study to others which were similar, the students were asked if they felt CAI allowed them to accelerate their learning. The data in table 22 shows their response to that question.

As observed from the data, about 70% of the students said that the computed did allow them to learn more information quicker and did like the opportunity to accelerate through the lesson. No actual figures of time reduction were kept, but most felt the difference to be significant and should be considered.

TABLE 22

DOES CAI ACCELERATE YOUR LEARNING?

Class	Yes	%	No	%
Freshman	27	84.4	5	15.6
Sophomore	30	78.9	6	15.8
Junior	31	64.6	12	25.0
Senior	42	60.0	24	34.3
Graduate	9	69.2	4	30.8
Totals	139	69.2	51	25.4
No Response	11	5.5%		

Related to the question of time, students were also asked if they would rather control the pace of a lesson manually or if it should be paced by a clock in the computer. Their responses were very much in favor of self control over machine control. Table 23 tabulates their answers.

TABLE 23

SELF-PACED VS MACHINE PACED LESSONS

Class	Self		Machine	
Freshman	30	93.8	2	6.3
Sophomore	37	97.4	0	0.0
Junior	45	93.8	1	2.1
Senior	64	91.4	2	2.9
Graduate	11	84.6	2	15.4
Totals	187	93.0%	7	3.5%
No Response	7	3.5%		

From these two items, it is obvious that students feel better about controlling the pace of the CAI lesson and are not hampered by the idea that they can go faster if they wish.

Attitude Toward CAI -

Previous research indicates that the majority of students feel positive about and like CAI as a mode of instruction. As part of this study, students in the experiment were asked about their attitude toward CAI. Table 24 lists their answers.

TABLE 24

ATTITUDE TOWARD COMPUTER LESSONS

Class	Liked It		Disliked It	
Freshman	25	78.1	6	18.8
Sophomore	31	81.6	4	10.5
Junior	42	87.5	5	10.4
Senior	49	70.0	16	22.9
Graduate	11	84.6	1	7.7
Totals	158	78.6%	32	15.9%
No Response	11	5 5%		

As shown the data from this study supports the findings from previous studies, as over 78% of the students said they liked to take CAI lessons. This is also a reminder that for those who do not have positive feelings about CAI, other alternatives for learning should be made available.

Related to attitude toward CAI is the ease with which a terminal can be operated, the personalization of instructional lessons and the feeling of being threatened by the computer. The following tables show the feedback from students regarding these three issues.

TABLE 25

TERMINAL OPERATION

Class	Easy		Difficult	
Freshman	28	87.5	4	12.5
Sophomore	38	100.0	0	0.0
Junior	43	89.6	5	10.4
Senior	58	82.9	7	10.0
Graduate	11	84.6	2	15.4
Totals	178	88.6	18	
No Response				

Based on the results, almost 90% of the students said that terminal operation was easy after experiencing several lessons. This leads to the concept that almost anyone can be taught to operate a terminal for CAI application if they possess fair to good learning skills.

To make the CAI lesson as tutorial as possible, an attempt was made to personalize instruction. Students were asked to type their first name into the computer as their primary instruction. From then on, the computer would call them by name as they progressed through the lesson. At the end of the course they were asked if this 'personalization' made them feel comfortable as they took a lesson. The data in table 26 summarizes their response.

TABLE 26

DID YOU LIKE THE PERSONALIZATION OF CAI LESSON

Class	Yes	%	No	%
Freshman	28	87.5	3	9.4
Sophomore	37	97.4	1	2.6
Junior	38	79.2	9	18.8
Senior	56	80.0	11	15.7
Graduate	12	92.3	1	7.7
Totals	171	85.1	25	12.4
No Response	5	2.5%		

From this we can conclude that students preferred a personalized program if possible.

Lastly, to check on the attitude of student toward the computer, they were asked if they felt threatened by the computer at any time while they were taking a lesson. Table 27 displays the results of that question.

The results of this question were interpreted to support that CAI is not a dehumanizing experience and should not greatly affect, in a negative sense, the students who use CAI for learning. It is hard to explain, however, why seniors feel twice as threatened by computer usage than any other single class. The freshman had the lowest score and thus the least amount of anxiety about CAI. There is some unexplain-

TABLE 27

WERE YOU 'THREATENED' BY THE COMPUTER

Class	Yes	%	No	%
Freshman	2	6.3	30	93.8
Sophomore	4	10.5	34	89.5
Junior	4	8.3	44	91.7
Senior	16	22.9	51	72.9
Graduate	0	0.0	13	100.0
Totals	26	12.9	172	85.6
No Response	3	1.5%		

ed inconsistency in this item. Could it be that 'technological threats' are learned? The data from this study was insufficient to determine why the difference existed. This is a problem which requires further study.

Grades vs Computer Lessons -

One of the basic underlying assumptions for the study was that CAI is an effective and efficient system of teaching and learning. To support this viewpoint, it was further assumed that the number of lessons taken by a student in any course would raise their final grade. Thus, if one student took five CAI lessons and another took ten, those with the most CAI lessons would receive the highest grade in the course. A correlation was run on these two factors. The results did show a positive relationship between the number of lessons and class grade. This value of sigma was .615. Analysis on a 'T' test showed this to be significant beyond the 1% level of confidence. This value of significance was much higher than anticipated. This high positive value leads one to believe that the CAI lesson materials do, in fact, help the student learn the concepts and principles of electronics.

Further correlations were run between the number of lessons and the lab grades. This value calculated to .517 which was lower than that computed for the class grade, but still beyond the 1% level of significance. In general it is concluded that CAI does help students learn both information and skill.

The average number of lessons taken by all students was 4.82 with a standard deviation of 2.93. This low number of lessons taken from a possible 24 CAI lesson available did produce a very high correlation. More lessons may even increase this level of significance.

As a matter of information, the average class grade earned by the students in the experiment was 2.854 (C+) on a 4.0 scale. The average lab grade was 3.226 (B). These scores are slightly above what would be expected from the normal curve. This positive skew could be due to the criterion evaluations used and the utilization of a 'mastery learning' environment. No data was collected about this problem and should be further studied.

Summary of Classroom Data -

The findings of this study do tend to show that CAI lessons can be generated by the teacher. Their effectiveness for learning is virtually the same. The students who take CAI lessons think positively about the system. They like to know how they are doing as they proceed through the tests and lesson materials, so sufficient feedback should be provided to them by the computer. The ability of a student to set his/her own pace of learning and the personalization of the lessons were well received.

Chapter V

SUMMARY, FINDINGS, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

This study dealt with the specific application of a micro-computer network as a multi-terminal interactive instructional system in a classroom environment. The technological advances in data processing and the advancing state of the art in hardware development make the microcomputer financially accessible to any school district, even specific classroom teachers. Its application for teaching purposes will increase greatly in the years ahead. This study was undertaken to look at some of problems which exist in adapting the micro-computer to a classroom instructional setting and to identify the specific skills which are required of the classroom teacher to utilize such a system.

Purpose of the Study

The main thrust of this study dealt with the application, restriction and feasibility of a micro-system as an interactive, tutorial, instructional tool in a self-contained classroom. More specifically the study attempted to answer the following questions:

1. What was the minimum system requirement for a four-terminal interactive, multi-user (time-share) extended basic system?

2. What was the optimum CPU memory capacity required for a four-terminal multi-user system?
3. What was the number of interactive tutorial lessons which could be stored on a floppy disk with a maximum lesson contact time of 50 minutes?
4. What was the optimum CPU partition size required to operate a multi-user interactive instruction/management system on a micro?
5. What relationships existed in the micro CAI system with its diagram book and the traditional, costly, self-paced, automatically programmed visual display system?
6. What were the attitudes of students toward an interactive tutorial CAI system as compared to 16 mm films, ½" video tapes and traditional teacher/lecture presentations?
7. What impact does the interactive CAI system have on retention of material, learning time and comprehension?
8. What human physical/psychological limitations exist in using a cathode ray tube (CRT) and a printer terminal as an instructional device?
9. What recommendations can be made for applications of a micro system as an educational adjunct to existing classroom instructions?
10. What limitations exist for a multi-user extended basic program using a micro system for interac-

tive computer assisted instruction in the classroom?

Limitations of the Study

1. Hardware

   The micro-computer system used in the study was an Altair 8800 with two floppy disk drives, three lear siegler ADM-1 CRT display terminals and one DEC-II printer. CPU memory capacity was 64K. A vector interrupt board handled input/output operations.

2. Program Language

   The computer language was Altair time/share extended disk basic, version 1.1 preliminary release.

3. Participants

   The information for the study was generated from industrial arts and technology class enrollments in IAT 180, Basic Electricity, IAT 281, Electro-Mechanical Equipment, and IAT 485, Digital/Micro-Processor Basics from spring 1978 through June 1980 at U.N.C., Greeley, Colorado.

4. Environment

   The classroom environment consisted of a multi-media electronics laboratory with a collection of films, video tapes, tape slides and a traditional text book resource center supplementing the computer. Also, 12 electronics test benches with test equipment were available.

5. Instructional Programs

Information for the study was obtained from information sheets and 70 CAI interactive lessons generated by the instructor, D. L. Jelden over the content of four course offerings at the U.N.C., Greeley, Colorado. The lessons were generated, with minor revisions, based on a model set by the U.S. Continental Army Command, CAI instruction project, U.S. Army Signal center and school, Ft. Monmouth, New Jersey, May 1971, Frank E. Giunti, Technical Director, Technical Report 71-2.

Methods and Procedures

To evaluate the application of a micro-computer to classroom use, a system was obtained and assembled. During the school year, 1975-76, Lloyd Thompson, a graduate student at U.N.C., completed the hardware package according to some specific operating limits which were to be incorporated based on pre-determined study.

A sample program was generated and programmed into the system using 'Basic' language. Familiarization with the system and program expansion continued during the 1976-77 school year.

From the spring of 1977 until the spring of 1978, 70 instructional lessons were written, tried out and modified as needed. Validating tests and the instructional model were accomplished and the study was begun with the spring quarter electronics enrollments in the electronics lab.

At the conclusion of each class, data was gathered from the participants of the study and processed at its conclusion. The findings of the study which follow are a summary of that data.

Findings

Instructional Lessons -

To generate CAI lesson materials, it is essential to analyze and diminish the content of a course to its basic elements. Further these elements must be further divided until an instructional unit which can stand alone is obtained. This instructional unit becomes the base from which instruction starts. These 'frames' of information, response items and evaluation or prover units, are then assembled to make up a larger body of knowledge. The details on how this was down is explained in the instructional model development section within the study. Unless the instructor is willing to evaluate the sequence, worth, and interrelationship of each part of their course content, CAI program generation is not possible.

The general guidelines for CAI lesson development follow.

1. The content of instruction shall be determined through content analysis and shall be specified

in terms of student performance objectives consisting of terminal performance and enabling objectives.

2. The pace of instruction shall be controlled by the individual student to the maximum extent consistent with effective educational practice.
3. Individual differences among students shall be taken into account to provide the most effective and efficient learning paths in line with student aptitudes and needs.
4. Extensive use shall be made of information feedback to assure response sensitive instruction.
5. The instruction shall be presented in a modified single mainline track. Branching, looping and other techniques shall be used to promote efficiency and effectiveness of instruction particularly for slow learners. Forward branching shall be used to increase the efficiency of instruction for fast learners and others with prior knowledge of the subject matter.
6. A system shall be established to evaluate student performance in terms of mastery of objectives.
7. Knowledge of results shall be provided to the student. Correct answers shall be confirmed and incorrect responses shall be followed by immediate remediation.
8. Progress to a new increment of instruction will

not be permitted unless a correct answer is obtained from the prior question.

9. Students shall be afforded the opportunity to recycle through those portions of the instruction in which failure to meet objectives is evident.

10. The mainline sequence of instructional frames shall be designed to achieve 85 percent correct responses by all students on the first try. Achievement of this objective shall be determined through analysis of student performance data by trial and error in sample programs.

11. Effective use shall be made of the instructor to assist students who encounter difficulty during instruction. The need for instructor assistance shall be determined under program control by failure of the student to meet specified performance criteria. In addition, instructor assistance shall be made available whenever requested by the student.

12. The instruction shall consist of practical (hands-on) training to the extent dictated by the objectives.

13. Verbal and practical (hands-on) training shall be carefully integrated to provide variety in presentation modes and to avoid over-dependence on verbal comprehension for mastery of concepts and

skills.

14. The major portion of the subject matter shall be converted to a CAI format. However, care must be exercised to avoid the use of CAI for instruction that can be presented just as effectively by more economical self-paced methods.
15. Liberal use shall be made of graphics diagrams, schematics, etc., in conjunction with verbal presentation of subject matter. These will be assembled into a diagram book.
16. Vocabulary control shall be exercised to keep reading comprehension requirements generally consistent with the reading ability of typical students. All programs will be written for the 10th grade level or below as determined by the FOG Readability Index.
17. Care shall be taken to avoid lengthy presentations prior to a call for a student response. No more than three frames will be presented without some student response, exceptions being review modules.

Hardware Considerations -

Based on developmental data and actual classroom experience with the Altair system, the following guidelines are given to those who would contemplate the purchase of a microsystem for educational purposes:

1. In selecting a micro-computer, the hardware (system) supplier should be readily available for

maintenance and service of whatever system is purchased. Those manufacturers which provide extensive information to the operator when asked, should be given strong consideration. Some manufacturers are reluctant to provide much technical information about their system. They should not be given first priority.

Also, only those manufacturers who have a strong and reliable reputation should be considered. If the supplier goes out of business as Altair did during the study, no support exists.

2. The capacity of the system should be at least 64 K-bytes or able to address at least that much data. Some systems are expandable and thus can provide additional memory. If the time/share operation is considered, self-contained or interfaced, the larger the system capacity the better. Research has shown that self-contained time/share is questionable at best with a system of less than 64 K-bytes of core memory.
3. Standardization with other systems in existence (disk drives, formatting, language, and interfacing) should be evaluated. Extensive program revisions, copying disks and adding additional boards can create problems if either the software or hardware needs to be changed. For ex-

ample, 100 pin buss systems make it possible to upgrade memory boards. The interchangeability of disks from system to system contributes to the exchange of programs and software among users. A unique system imposes limitations on one's alternatives.

4. If time/share is important, CRT's should be standard RS-232C compatible. Also, if special clear screen commands are employed in framing information, the terminals should have a similar ASCII code for "clear screen and home cursor." Even different models of a particular system may be uncompatible. For example, an ADM-1 and an ADM-3 uses (26). In effect, this would require minor program modifications to be used in a classroom setting.
5. Maintenance funds should be provided for upkeep and replacement parts. From December 2, 1976 until July 1, 1980, a total of $1483.65 was spent to maintain or upgrade the system. This cost was for 4029 plus hours of operation. Roughly computing, the cost of maintenance was approximately $500.00 per year on a $10,000 investment or about five percent of its initial cost. If improvements are to be incorporated into the system as technology changes, 10 percent of the cost of the equipment is not out of line. Also, the

life expectancy of the computer was anticipated to be about 5000 hours.

The cost of system maintenance broke down in the following manner (3½ year period):

Alignment of Disk Drives (every 1000 hours)	$ 200.00
Terminal Repair/Maintenance	$ 280.00
New Memory Boards (CPU)	$1003.65
Total	$1483.65

If considerable programming is to be done, the cost of 8" floppy diskettes will run approximately $5.50 per disk. The 70 lessons and their back-up copies included a total of 54 disks. The cost for these disks alone came to around $297.00. For a small program, this is a factor to compute in the operation and maintenance budget. This additional cost was not computed in the previous budget record of $1483.65.

6. Because the system was designed for Outreach educational purposes in the region, the increased wear and tear of moving the units at least once a week in the trunk of a car did raise the cost of maintenance. In fact, the disks were the most fragile of the whole system. Their reliability was altered considerably when they were moved often. A permanent installation may encounter a lower need for repetitive disk alignments.

Also, the quality of the disk drives will have much input on how rugged the system is. The Altair drives were a little suspect after 500 to 1000 hours of use. Disk reliability should be completely evaluated.

7. The operating system, in addition to the disk reliability, created some problems. A dependable system must have an operating system that is fast, dependable and flexible. The re-configuration routine in the Altair was such that as more disks were added or ports addressed, the reliability of the system went down. For example, if four users tried to save programs on the disks at intermittent times, many I/O errors were made. At times, the system would even lock up and re-initializing the entire system was callled for. To this end, any student who was taking a lesson or who was programming, lost all of their data. Many hard feelings were generated over this problem. Therefore, any MP/M or reliable time/share operating system should be proven before the CAI program is adopted.

Human Considerations of CAI -

Students in each class were asked to take at least a minimum of five lessons on the computer. However, the data shows that the average number of lessons taken by each student was 4.82, slightly less than the five expected. This difference was assumed to be within an acceptable level and that the data obtained would produce the results necessary.

The total population of the study consisted of 181 boys and 20 girls enrolled in three electronics classes over a period of seven quarters. The three classes studied had approximately the same number of freshman, sophomores, and juniors, with a slightly larger number of seniors. The graduate students made up the smallest class of the study. The population was predominately industrial arts majors (70%) with a total or 18 different majors being represented.

Half of the students involved in the study had previous experience with terminal operation prior to their enrollment in the electronics program.

Not quite two-thirds of the students in the study used the computer as an initial contact with the course materials, even though other media were available, such as films, video-tapes, tape-slides, and traditional text books.

Student anxiety toward terminal operation was about average prior to instruction with a large decrease after lesson experience as expected.

The average length of time required for each lesson was split between 15-30 minutes (36.8%) and 30-45 minutes (29.9%). This falls within the estimated time, 30-50 minutes, which was predicted prior to the study. Of the students, 88.1%, did complete the lessons under 60 minutes with 75.2% finishing in 45 minutes or less.

The rate of terminal display most suggested was 9600 baud. Ninety-three point five percent indicated that 9600 baud was about right.

The diagram books were found to be adequate as indicated by 94% of the participants.

Test validity and difficulty were judged by the respondents who agreed that the test items did relate to the objectives of the course and that their difficulty was within reason.

Even though class enrollments varied from 12 to 30 students, only 21.4% indicated that the terminals were not free when they wanted to take a lesson. There were times when the terminals were not used extensively during class time.

Seventy-four percent of those responding said the computer was as useful or better than other media available to learn the concepts and principles addressed by the lessons. In addition 90.5% said that the computer lessons were as good as or better than other media in helping them remember the information and skills.

Several students complained of physical problems with the CRT terminal operation. One student could not use the CRT because it produced nausea. About 21% complained of eye strain after about 30 minutes use.

Because of system limitations, a slight delay of 5-15 seconds was required to retrieve lesson modules from disk storage. Only 8% indicate this delay presented a problem in the instruction. The disk operation was found to be somewhat unreliable as I/O and file link errors did occur from time to time. Investigation showed this to be a mechanical problem with disk alignment and extended use.

The readability and lesson terminology were evaluated with the FOG Index of Readability and actual student use. Ninety-six percent said that the lessons were easily read and understood. All lessons were written at the 10th grade level or below.

Fifty-three percent of the students said that the computer could teach them basic skills. Specifically the operation of voltage and current measurement was explained.

Although no direct relationship existed between CAI test items and the course midterm and final exams, 80% of the students felt that the CAI experience using pre-post tests did allow them to do better in the course objective examinations.

With both teacher made and computer generated tests available, no significant agreement was reached by the students on which they preferred. About 50% said it made no difference and the other half were divided equally between either type.

The students did overwhelming indicate that immediate feedback on test items was preferred. This was agreed to by 91.5% of those answering.

Over 69% of the respondents said that CAI did accelerate their learning and 93% indicated that they preferred to pace their own lesson rather than letting the computer time pace it.

The general attitude of students toward the computer was positive as 78.6% said they liked it. Further 88.6% said terminal operation was easy after experienceing several lessons.

An attempt was made in the generation of the lesson to personalize it. Of those taking CAI lessons 85.1% said they liked this touch. Also, 85.6% indicated that they were not threatened by the computer and had no anxiety toward it after several lessons.

Finally, CAI lessons showed a positive relationship to grades received in the class and lab. The study showed that the more lessons taken the higher the grades received. This level of significance was well above the 1% level, both for class and lab grades, which shows that chance was not a major factor.

CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

Based on the findings of the study and in response to the specific questions raised in the purpose of the study, the following conclusions are drawn.

A minimum four-terminal interactive time/share instructional system should have at least 64K-bytes of computer/memory capacity in the CPU. Of that, 40K-bytes should be available for terminal use, with 10K-bytes per terminal.

Automatic initialization of computer operating system should be included in the system in a separate PROM or other device and should not be located as part of the CPU capacity.

At least two disk drives should be accessible to the system. If possible one should be a floppy for program generation, management and backup, the other a hard disk for instructional program storage. The hard disk should have a capacity of at least 12 megabytes of data if 50 or more lessons are to be programmed into it.

The program language used should be a universal type, similar to basic, pascal, fortran, etc. For educational purposes, a specialized language like pilot or some CAI management operation might be used. The key factor is simplicity. It should be easily learned and applicapable to an educational environment, particularly student use. Some systems make use of CP/M or MP/M management systems. These systems increase the speed of file handling and allow for multi-language programming in a small system. CP/M and MP/M do take more core memory for operation than do single language systems like basic. Whatever the language, it should allow for the reading and writing of random files from all terminals and a high degree of reliability in data manipulation. Protection codes for each file should be available in the system.

Based on this study, four lessons could easily be stored in ASCII code on a standart 300K-byte 8" floppy disk. If the lessons were stored in digital, the capacity was increased to five or six lessons. From this fact, if maximum lesson availability to lessons is important, and the number of interactive lessons exceed six, then a greater disk capacity is needed. The average number of lessons required for this experiment ran from six for IAT 485 to 24 for IAT 180. It is anticipated that up to 100 lessons could be stored on a 12 megabyte disk, therefore extending classroom operation to several classes simultaneously.

An additional hardware consideration is the compatibility of the disk drives. Unique systems prohibit the reading and exchanging of programs in user groups. A standard disk formating and disk operating system is recommended for educational purposes so lessons can be shared with other users, schools, classrooms, etc. This consideration should be addressed immediately by the industry. If audio/video tape systems can be compatible, why not some computer memory systems.

The writing of educational programs for computer application is feasible. An instructional model or teaching plan needs to be established to improve the effectiveness or efficiency of teaching. To do this requires that the teacher know the subject and the characteristics of the students to be taught. All instruction should be within the ability level of the students, both in reading and concept comprehension.. The utilization of terminal performance objectives and criteria referenced evaluation should be used to improve educational accountability of the CAI system. Where useful, supplemental diagram books or instructional aids (audio/visual) should be incorporated into the CAI lesson. Their utilization increases comprehension and increases learning speed. High cost audio/visual systems are not required for CAI.

Based on this study and previous research in CAI, students, in the main, like computerized instruction as well as or better than the traditional forms of media, such as films, video-tapes and tape-slides. CAI program development is no more difficult than the generation of good video-tapes, films, or slides. All are within the capability of a good teachers skills.

From the findings of this study, the students ability to retain the information learned from CAI was as good as or better than the other common media, such as video-tapes, films, and tape-slides. The proposed reason being the necessity of students to overtly respond to information in the program rather than to passively observe. In this light, it is possible to teach some skills required by directing students to manipulate dials, controls, etc., on small pieces of equipment if made available by the terminal. Extended further, the utilization of simulation devices controlled by the computer are distinct possicilities in CAI. The pilot training programs in most airlines now utilize this system.

In using CRT's for CAI instruction, teachers need to be aware of the physical/psychological factors for each student. Students who cannot see well, have problems reading, and who are 'psyched' out by the system should not be required to use it. Modifications of existing systems might be required for some. For example, large screen display (TV) for visually impaired students is easily done with a CRT display. Audio speech synthesizers incorporated with the computer lesson might be used also.

This study has shown that an effective CAI instruction system can be developed with a micro-processor system and that the economics of it are well within most educational budgets. It is imperative that teacher education systems should provide extensive outreach or inservice programs on CAI for those teachers in the field and that CAI courses be included in the existing teacher education programs in all colleges and universities. The application of computers to education has just begun and the future is virtually unlimited. Tomorrows classroom teacher will be asked to operate small computers just as they are now required to run videotape machines, movie projectors and cassette players.

RECOMMENDATIONS FOR FUTHER STUDY

1. Industries manufacturing micro-processors for educational purposes should be made aware of the needs of teachers and given assistance by the educational community on how new small computers can be used in the classroom.
2. Research should be started on the application of

micro computers for simulation purposes in an educational environment. What subject fields and what levels of instruction might best be served by the computer.

3. Specialized applications of CAI on large screen displays for the visually handicapped might be initiated. Likewise, the incorporation of speech synthesizers for the blind might be researched.
4. In an educational environment, research should be done on the physiological factors of students and the problems of CRT display. Modifications in hardware or environment that can be made to reduce eye strain and discomfort need to be identified.
5. Some students were apprehensive about computer operation and usage. A study should be conducted on the psychological fears that students have or learn regarding computer operation.
6. Further study should be done into the relationship of CAI lessons, criterion objectives, mastery learning and student attitudes toward learning.

APPENDIX A

SAMPLE OF ALTAIR "COURSEWRITER"

by William K. Jackson*

The ease with which the author can use the system is facilitated by the author command codes. Each line of the lesson the author enters into the system is preceded by a code indicating its function. The types of commands an author can enter and their meanings are as follows:

Mnemonic	Definition
QU	The presentation of a question. The text portion of the entry will be displayed and an answer will be requested.
QG	The same as QU except that the question will be graded.
CA	A correct answer. The text portion of the entry is compared to the answer supplied by the student.
WA	An anticipated wrong answer. The text portion of the entry is compared to the answer supplied by the student.
UA	An unanticipated answer. This command provides a logic point for answers supplied that are not CA or WA.

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*Unpublished doctoral dissertation, University of Northern Colorado, Greeley, fall 1977.

DS	Display of text at a major level. This command causes the text portion of the entry to be unconditionally displayed.
TX	Display of text at a minor level. This command causes the text portion of the entry to be conditionally displayed. The condition for a display is a match on the preceding CA, WA or UA statement only.
BR	Unconditional branch. This operation will cause the lesson to resume at a position in the lesson other than the next major statement in sequence.
LB	Course labeling or segmentation. This command allows the course to be broken into segments and assigns a name to each segment. This feature allows a pointer to be created for branching and reentry into the system.

This source program is the latest for CAI management and operation. It is designed to operate in any S-100 CP/M or MP/M disk hardware.

Program Name : Isscai System

Hardware System : Standard CP/M or MP/M

Minimum Memory Size: 8K

Language : 8080 Assembler

Description : This is a set of three programs CAIGEN, TUTOR, and ENROLL which provide, with the use of a system editor, a complete COMPUTER AIDED INSTRUCTION system. CAIGEN formats an editor written text file to the requirements of TUTOR and creates an enrollment file for the course if needed. TUTOR is the heart of the system providing forward and reverse linking of text, prompting for answers even where there might be several that are correct, responding on correct or incorrect answers with replys if wanted, chaining to next lesson, scoring, passwords, comments, and several other functions. ENROLL provides complete enrollment file maintenance and teacher monitoring of student progress in a course, lesson by lesson, this program has password level access.

Resease : Currently Available

Price : $250.00

Included in Price : Object of three programs and users manual. System is available for resale license.

Author : G. B. Shaffstall

Where to Purchase : International Software Service
13050 W. Cedar Drive #15
Lakewood, Colorado 80228
303-986-7664

A SAMPLE 'CAI' PROGRAM

```
This is written by D. L. Jelden - UNC.  Code
on disk is "D C MOTOR"
.CC
.CS
As shown in Figure 3, the permanent magnetic
field is distorted because of the interaction
of the electromagnetic and permanant magnetic
fields.
.PA
.CS
The need for lines of force to find the short-
est distance and opposition of the two magnetic
fields produces -?- in the rotor.
    A.  Resistance
    B.  Torque
    C.  Energy
    D.  Force
.QU
A
C
D
B
.IA
How's that?  Try again.  This time type A, B,
C, or D.
.AN
Resistance!!  Fat chance.  That characteristic
does not change once the armature is made.
Try again.
.LB
.AN
Could be.  But that's not what I'm looking for.
Try again.
.LB
.AN
That's partly right.  However, what is the term
we gave to that turning force?  Try again.
.LB
.AN
Right on.  Torque is the turning force generat-
ed by the interaction of magnetic fields.
.CC
If the loop is laying in a horizontal position
and electric current is applied to it.  The
torque produced will move the loop from a hori-
zontal to a vertical position as shown in Fig-
ure 4.
.PA
```

The torque produced by each side of the loop aid each other in the horizontal posetionp

.PA

When the poop reaches the vertical position, the turning force or 'Torque' is stopped because each side of the loop is now working against each other.

This position is a condition of minimum torque. (See Figure 4).

APPENDIX B

PROGRAMS WRITTEN BY DR. CARL CROSSWHITE, UNIVERSITY OF NORTHERN COLORADO COMPUTER CENTER, TO MANAGE CAI SYSTEM.

```
LOAD"CMI LOAD",O
OK
LIST

10 DIM Y$(24),Z$(24) ' CREATE AND LOAD C.M.I. FILE
20 C$=CHR$(27) + ";"
30 PRINT C$;
40 PRINT"THE PURPOSE OF THIS PROGRAM IS"
50 PRINT"TO LOAD THE C.M.I. FILE IT"
60 PRINT"SHOULD BE USED AT THE BEGINNING"
70 PRINT"OF EACH QUARTER. THE PROGRAM"
80 PRINT"ALSO INITIALIZES THE PRE-TEST"
90 PRINT"AND POST-TEST SCORES FOR EACH"
100 PRINT"STUDENT AS WELL AS DETERMINING"
110 PRINT"THE STUDENT'S C.A.I. I.D. NO."
120 PRINT"FOR CROSS-CHECKING THE USER'S"
130 PRINT"IDENTITY."
140 PRINT"PUSH THE RETURN KEY TO CONTINUE.";
150 LINE INPUT A
160 PRINT C$;
170 PRINT"TYPE IN COURSE NAME AND NUMBER."
180 PRINT"FOR EXAMPLE: IA 281";
190 INPUT N$
200 PRINT
210 PRINT"LOAD C.M.I. DISK ON DRIVE #1 AND"
220 PRINT"PUSH THE RETURN KEY WHEN READY.";
240 LINE INPUT A$
260 PRINT C$;
270 PRINT"TYPE THE STUDENT INFORMATION AS"
280 PRINT"FOLLOWS;"
290 PRINT"UNDER TYPE:"
300 PRINT"----- -----"
310 PRINT"  S        UNC/SSN I.D. NUMBER"
320 PRINT"  L        STUDENT'S LAST NAME"
330 PRINT"  F        STUDENT'S FIRST NAME"
340 PRINT"  M        STUDENT'S MID INITIAL";
350 PRINT
360 PRINT"USE THE SPACE BAR TO ALIGN"
370 PRINT"THE CURSOR UNDER EACH FIELD"
383 PRINT"PUSH THE RETURN KEY TO CONTINUE.";
385 LINE INPUT A$
387 PRINT C$;
390 PRINT"EACH LINE WILL BE GIVEN A"
400 PRINT"HEADING. BE CERTAIN TO RECORD"
410 PRINT"THE STUDENT'S C.A.I. I.D. NO."
420 PRINT"AFTER EACH ENTRY.  LET'S BEGIN."
430 OPEN "R",#1,N$,1
440 FIELD #1,9 AS S$,15 AS L$,7 AS F$,1 AS M$
450 FOR I=1 TO 24
```

```
460 FIELD #1,(I+7)*4 AS A$,2 AS Y$(I),2 AS Z$(I)
470 NEXT I
480 FOR I=1 TO 2046
490 PRINT"PUSH THE RETURN KEY TO CONTINUE.";
500 LINE INPUT A$
510 PRINT C$;
520 PRINT
530 PRINT"SSSSSSSSSLLLLLLLLLLLLLLLFFFFFFFM"
540 LINE INPUT B$
550 IF B$="" THEN END
560 FOR J=1 TO 24
570 LSET Y$(J) = MKI$(0)
580 LSET Z$(J) = MKI$(0)
590 NEXT J
600 LSET S$ = LEFTS(B$,9)
610 LSET L$ = MID$(B$,10,15)
620 LSET F$ = MDI$(B$,25,7)
630 LSET M$ = RIGHT$(B$,1)
640 PUT #1,I
650 PRINT"STUDENT C.A.I. I.D. NO.=";I
660 PRINT"PLEASE RECORD THE C.A.I., "
670 PRINT"I.D. NUMBER AT THIS TIME"
680 NEXT I
690 END
OK
```

```
LOAD"CMI EXTD",0
OK
LIST

5 REM - CMI EXTD
10 DIM Y$(24),Z$(24) ' EXTEND AN ALREADY CREATED C.M.I. FILE
20 C$ = CHR$(27) + ";"
30 PRINT C$;
40 PRINT"THE PURPOSE OF THIS PROGRAM IS"
50 PRINT"TO EXTEND A C.M.I. FILE AFTER IT"
60 PRINT"HAS BEEN INITIALIZED. IT IS"
70 PRINT"NECESSARY TO KNOW THE LAST C.A.I."
80 PRINT"I.D. NO. THAT WAS ON THE C.M.I."
90 PRINT"FILE. IF THIS PROGRAM IS USED"
100 PRINT"WITH A C.A.I. I.D. NO. OF AN"
110 PRINT"ALREADY EXISTING STUDENT, HIS/"
120 PRINT"HER PRE-TEST/POST-TEST SCORES"
130 PRINT"WILL BE DESTROYED. IF IN DOUBT,"
140 PRINT"THEN USE THE CNTRL-C RESPONSE TO"
150 PRINT"STOP THE RUNNING OF THIS PROGRAM."
160 LINE INPUT A$:PRINT C$;
170 PRINT"BETTER SAFE THAN SORRY. ONCE A"
180 PRINT"MISTAKE IS MADE, IT IS HARD TO"
190 PRINT"RECOVER. SURE YOU WANT TO GO ON."
200 PRINT"ANSWER YES OR NO.";
210 INPUT A$: PRINT C$
220 IF A$<> "YES" THEN END
240 PRINT"TYPE IN COURSE NAME AND NUMBER."
250 PRINT"FOR EXAMPLE: IA281";
260 INPUT N$: PRINT C$;
280 PRINT"LOAD C.M.I. DISK ON DRIVE #1 AND"
290 PRINT"PUSH THE RETURN KEY WHEN READY.";
300 UNLOAD 1
310 LINE INPUT A$: PRINT C$;
320 MOUNT 1
340 PRINT"TYPE THE STUDENT INFORMATION AS"
350 PRINT"FOLLOWS:"
360 PRINT"UNDER     TYPE:"
370 PRINT"  S       STUDENT I.D. NUMBER"
380 PRINT"  L       STUDENT'S LAST NAME"
390 PRINT"  F       STUDENT'S FIRST NAME"
400 PRINT"  M       STUDENT'S MIDDLE INITIAL"
410 LINE INPUT A$: PRINT C$
420 PRINT"EACH LINE WILL BE GIVEN A"
430 PRINT"HEADING. BE CERTAIN TO RECORD"
440 PRINT"THE STUDENT'S C.A.I. I.D. NO."
450 PRINT"AFTER EACH ENTRY.  LET'S BEGIN."
460 OPEN "R", #1, N$,1
470 FIELD #1,9 AS S$,15 AS L$,7 AS F$,1 AS M$
480 FOR I=1 TO 24
490 FIELD #1,(I+7)*4 AS A$,2 AS Y$(I),2 AS Z$(I)
500 NEXT I
510 FOR I=1 TO 24
520 LSET Y$(I)=MKI$(0)
```

```
530 LSET Z$(I)=MKI$(0)
540 NEXT I
550 PRINT"INPUT THE LAST C.A.I. I.D. NO."
560 PRINT"ENTERED ONTO THIS C.M.I. FILE."
570 INPUT J: PRINT C$;
580 J = J + 1
590 FOR I=J TO 2046
600 PRINT
610 PRINT"SSSSSSSSSLLLLLLLLLLLLLLLFFFFFFFM"
620 LINE INPUT B$
630 IF B$="" THEN END
640 LSET S$=LEFT$(B$,9)
650 LSET L$-MID$(B$,10,15)
660 LSET F$=MID$(B$,25,7)
670 LSET M$=RIGHT$(B$,1)
680 PUT #1,I
690 PRINT"STUDENT C.A.I. I.D. NO. = I";
700 NEXT I
710 END
OK
```

```
LOAD"CAI INTR",0
OK
LIST

1 REM N=CAI I.D. NUMBER
2 REM N$=STUDENT NAME (FIRST NAME)
3 REM S$=SOCIAL SECURITY NUMBER
4 C$=CHR$(27)+";"
5 PRINT C$;
10 PRINT"PLEASE ENTER YOUR CAI I.D. NUMBER"
11 PRINT"THIS IS NOT YOU UNC STUDENT"
12 PRINT"I.D. NUMBER, BUT IT'S THE"
13 PRINT"NUMBER THAT WAS ASSIGNED BY YOUR"
14 PRINT"INSTRUCTOR."
15 INPUT N
16 REM Y=PRETEST SCORES, Z=
17 REM POST TEST
18 OPEN "R",#1,"CMI FILE",1 ´ CHANGE CMI FILE TO ACTUAL CLASS
                                 NUMBER
19 DIM Y$(24),Z$(24)
20 FIELD #1,9 AS S$,15 AS L$, 7 AS N$,1 AS M$
21 FOR I=1 TO 24
22 FIELD #1,(I+7)*4 AS A$,2 AS Y$(I),2 AS Z$(I)
23 NEXT I
24 GET #1,N
25 PRINT"PLEASE ENTER YOUR UNC STUDENT I.D."
26 PRINT"NUMBER"
27 INPUT A$
28 IF A$<>S$ THEN END
OK
```

```
LOAD"PRETEST",0
OK
LIST

1 C$=CHR$(27)+";": PRINT C$;
5 I=CN*100/(NUMBER OF QUESTIONS)
10 PRINT""N$", YOUR SCORE ON THE PRE-TEST"
20 PRINT"WAS "CN" OR "I"%.  IF YOU MISSED MORE THAN"
30 PRINT"ONE OF THE (?) QUESTIONS YOU MUST"
40 PRINT"TAKE THE LESSON. TO RECORD THE SCORE"
50 PRINT"OF YOUR PRE-TEST, TYPE "R" AND PUSH"
60 PRINT"THE RETURN KEY."
70 INPUT R$:PRINT C$;
80 IF R$<>"R" THEN 110
85 IF R$="R" THEN 130
110 PRINT"I DON'T KNOW WHAT YOU PUSHED, BUT"
120 PRINT"IT WASN'T AN 'R', TRY AGAIN.":GOTO 70
130 LSET Y$ (LESSON NUMBER)=MKI$ (I)
140 PUT #1,N
150 IF I=>80 THEN 170
160 IF I<80 THEN340
170 PRINT"YOUR SCORE ON THE PRE-TEST WAS"
180 PRINT"HIGH ENOUGH TO ALLOW YOU TO SKIP"
190 PRINT"THE LESSON, YOU MANY NOW EITHER"
200 PRINT"TAKE THE LESSON OR THE POST-TEST."
210 PRINT"TYPE 'A' FOR THE LESSON AND 'B' FOR"
220 PRINT"THE POST-TEST."
230 INPUT Z$
240 IF Z$="A" THEN 300
250 IA Z$="B" Then 330
260 PRINT"I DON'T KNOW WHAT YOU PUSHED, BUT"
270 PRINT"IT WASN'T AN 'A' OR 'B', THIS TIME PUSH"
280 PRINT"'A" FOR THE LESSON AND 'B' FOR POST-TEST."
281 PRINT"TRY AGAIN."
290 GOTO 230
300 PRINT"PUSH THE RETURN KEY TO CONTINUE)"
310 GOTO 380
320 LINE INPUT A$:PRINT C$;
330 RUN"ELEC#(?)",O:REM - POST TEST CODE
340 PRINT"I'M SORRY "N$", YOUR SCORE ON THE"
350 PRINT"PRE-TEST WILL NOT ALLOW YOU TO SKIP"
360 PRINT"THE LESSON. PUSH THE RETURN AND"
370 PRINT"WE WILL GET ON WITH IT.":GOTO380:LINE INPUT A$:PRINT
                                            C$;
380 SCRIPT FOLLOWS
OK
```

```
LOAD"POSTTEST",0
OK
LIST

10 I=CN*100/(NUMBER OF QUESTIONS)
20 PRINT""N$", YOUR SCORE ON THE POST-TEST"
30 PRINT"WAS "CN" OR "I"%."
40 PRINT"TO RECORD THE SCORE OF YOUR POST-TEST,"
50 PRINT"TYPE 'R' AND PUSH THE RETURN KEY."
60 INPUT R$
70 IF R$="R" THEN 110
80 IF R$<> "R" THEN 90
90 PRINT"I DON'T KNOW WHAT YOU PUSHED, BUT"
100 PRINT"IT WASN'T AN 'R'. TRY AGAIN.":GOTO 60
110 LSET Z$ (LESSON NUMBER)=MKI$ (I)
120 PUT #1,N
130 IF I<80 THEN 150
140 IF I=>80 THEN 210
150 PRINT"IF YOU MISSED MORE THAN ONE OF THE"
160 PRINT"(?) QUESTIONS, THEN YOU MUST COME"
170 PRINT"BACK AT A LATER TIME AND TAKE THE"
180 PRINT"POST-TEST AGAIN. ASK YOUR INSTRUCTOR"
190 PRINT"FOR ADDITIONAL INFORMATION."
200 END
210 PRINT"GOOD GOING. TRY TO REMEMBER"
220 PRINT"WHAT YOU LEARNED HERE AS IT MAY BE USEFUL"
230 PRINT"TO YOU IN THE FUTURE. GOOD LUCK."
240 END
OK
```

```
LOAD"CMI REPT",0
OK
LIST

10 DIM X$(24),Y$(24),Z$(24) ' PRODUCE A PROGRESS REPORT FOR
                                   C.A.I. COURSE
20 DATA " 1"," 2"," 3"," 4"," 5"," 6"," 7"," 8"," 9","10",
                                   "11","12"
30 DATE "13","14","15","16","17","18","19","20","21","22",
                                   "23","24"
40 FOR I = 1 TO 24
50 READ X$(I)
60 NEXT I
70 C$ = CHR$(27)+";"
80 PRINT C$;
90 PRINT "TYPE IN COURSE NAME AND NUMBER."
100 PRINT "FOR EXAMPLE:  IA 180";
110 INPUT N$
120 PRINT
130 PRINT "LOAD C.M.I. DISK ON DRIVE #1 AND"
140 PRINT "PUSH THE RETURN KEY WHEN READY."
160 LINE INPUT A$
190 OPEN "R",#1, N$,1
200 FIELD #1,9 AS S$,15 AS L$,7 AS F$,1 AS M$
210 FOR I = 1 TO 24
220 FIELD #1,(I+7)*4 AS A#,2 AS Y$(I),2 AS Z$(I)
230 NEXT I
240 K = 0
245 N = LOF(1)
250 FOR I = 1 TO N
260 PRINT "PUSH RETURN TO CONTINUE.";
270 LINE INPUT A$
280 PRINT C$;
290 GET #1,I
300 PRINT S$,F$,M$,L$
301 J=0
305 FOR K-1 TO 8
310 FOR L = 1 TO 3
315 J=J+1
320 PRINT USING"|      |";N$;
321 PRINT USING"||";X$(J);
322 PRINT USING "####";CVI(Y$(J));
323 PRINT USING "####";CVI(Z$(J));
324 PRINT USING "|  |";"";
330 NEXT L
335 PRINT
340 NEXT K
360 NEXT I
370 END
OK
```

APPENDIX C

SAMPLE LESSON WITH MANAGEMENT PROGRAM INCORPORATION IN PRE-TEST AND INTRODUCTION

```
0 REM WRITTEN BY D. L. JELDEN, UNC, 1976
10 REM N=CAI I.D. NUMBER
20 REM N$=STUDENT NAME (FIRST NAME)
30 REM S$=SOCIAL SECURITY NUMBER
40 C$=CHR$(27)+";"
50 PRINT C$;
60 PRINT"PLEASE ENTER YOUR CAI I.D. NUMBER"
70 PRINT"THIS IS NOT YOU UNC STUDENT"
80 PRINT"I.D. NUMBER, BUT IT'S THE"
90 PRINT"NUMBER THAT WAS ASSIGNED BY YOUR"
100 PRINT"INSTRUCTOR."
110 INPUT N
120 REM - Y = PRE-TEST SCORES
130 REM - Z = POST-TEST SCORES
140 OPEN "R", #1,"IA 180",1
150 DIM Y$(24),Z$(24)
160 FIELD #1,9 AS S$, 15 AS L$, 7 AS N$, 1 AS M$
170 FOR I=1 TO 24
180 FIELD #1,(I+7)*4 AS A$, 2 AS Y$(I), 2 AS Z$(I)
190 NEXT I
200 GET #1,N
210 PRINT"PLEASE ENTER YOUR UNC STUDENT I.D. NUMBER."
220 INPUT A$
230 IF A$<>S$ THEN END
240 PRINT C$;
250 PRINT"THANKS "N$", GLAD TO MEET YOU."
260 PRINT:PRINT"AND NOW ON WITH THE LESSON."
270 PRINT"PUSH THE RETURN KEY WHEN YOU"
280 PRINT"WISH TO CONTINUE YOUR PROGRAM"
290 LINE INPUT A$
300 PRINT C$;
310 PRINT"CONPUTER ASSISTED INSTRUCTION
320 PRINT"    DEMONSTRATION LESSON"
330 PRINT"  POWER IN ELECTRICAL CIRCUITS"
340 PRINT"          -------"
350 PRINT"      BY D.L. JELDEN"
360 PRINT"UNIVERSITY OF NORTHERN COLORAD"
370 PRINT"   INDUSTRIAL ARTS DEPARTMENT"
380 PRINT"       GREELEY, COLORADO"
390 PRINT
400 PRINT" (PUSH THE RETURN KEY TO GO ON)";
410 LINE INPUT A$
420 PRINT C$;
430 PRINT"  THIS COMPUTER CAN DO MANY"
440 PRINT"THINGS OTHER THAN CALCULATE"
450 PRINT"LARGE MATH PROBLEMS "N$" , IT"
460 PRINT"CAN ALSO PRESENT INFORMATION"
470 PRINT"TO YOU JUST LIKE A TEACHER."
480 PRINT"TO SEE HOW THIS IS DONE AND"
```

```
490 PRINT"TO LET YOU EXPERIENCE COMPUTER"
500 PRINT"ASSISTED INSTRCUTION, I'M"
510 PRINT"GOING TO GIVE YOU A SAMPLE"
520 PRINT"LESSON ON ELECTRICAL POWER, WORK"
530 PRINT"FORCE, AND ENERGY.";
540 LINE INPUT A$
550 PRINT C$;
560 PRINT"  TO BEGIN THIS LESSON, " N$
570 PRINT"LET'S REVIEW WHAT WILL HAPPEN"
580 PRINT"AS YOU RUN THIS PROGRAM."
590 PRINT
600 PRINT"  FIRST WE WILL SHOW YOU HOW TO"
610 PRINT"USE THE KEYBOARD AND TERMINAL."
620 PRINT
630 PRINT"  SECOND, WE WILL GIVE YOU THE"
640 PRINT"LESSON OBJECTIVES AND A PRE-"
650 PRINT"TEST OVER THOSE OBJECTIVES"
660 PRINT
670 PRINT"  LAST, WE WILL DO SOME TEACHING.";
680 LINE INPUT A$
690 PRINT C$;
700 PRINT"  TO BEGIN "N$" , YOU WILL NEED"
710 PRINT"TO TALK WITH ME BY TYPING YOUR"
720 PRINT"ANSWERS AND ENTERING THEM INTO"
730 PRINT"MY MEMORY FOR VERIFICATION."
740 PRINT"  TO ENTER YOUR ANSWER, FIND"
750 PRINT"THE RETURN KEY AND PUSH IT"
760 PRINT"AFTER YOU HAVE TYPED YOUR"
770 PRINT"ANSWER.  LET'S TRY IT.  TYPE"
780 PRINT"THE LETTER 'C' ON THE KEYBOARD"
790 PRINT"AND PUSH THE RETURN KEY.";
800 PRINT
810 INPUT A$
820 IF A$="C" THEN 930
830 PRINT C$
840 PRINT"I DON'T KNOW WHAT YOU PUSHED"
850 PRINT N$ ",  BUT IT SURE WASN'T A 'C'."
860 PRINT"TRY IT AGAIN.  THIS TIME FIND"
870 PRINT"THE 'C' ON THE KEYBOARD, PUSH"
880 PRINT"IT GENTLY, AND THEN PUSH THE"
890 PRINT"RETURN KEY ON THE KEYBOARD.";
900 LINE INPUT A$
910 IF A$="C" THEN 930
920 GOTO 830
930 PRINT C$;
940 PRINT"VERY GOOD "N$" , NOW THAT YOU"
950 PRINT"HAVE MASTERED THE OPEATION OF"
960 PRINT"MY TERMINAL, LET'S TAKE A CLOSER"
970 PRINT"LOOK AT THE OBJECTIVES OF THIS"
980 PRINT"LESSON."
990 PRINT
1000 PRINT"TO CONTINUE, TYPE 'C' AND"
1010 PRINT"PUSH THE RETURN KEY."
```

```
1020 LINE INPUT A$
1030 IF A$="C" THEN 1050
1040 GOTO 1000
1050 PRINT C$;
1060 PRINT"THE OBJECTIVES FOR THIS LESSON"
1070 PRINT"ARE AS FOLLOWS:"
1080 PRINT"  1.  TO UNDERSTAND THE TERMS"
1090 PRINT"      WORK, FORCE, AND ENERGY."
1100 PRINT
1110 PRINT"  2.  TO DEFINE ELECTRICAL POWER"
1120 PRINT
1130 PRINT"  3.  TO SHOW THE RELATIONSHIPS"
1140 PRINT"      OF WORK, FORCE, ENERGY,"
1150 PRINT"      TIME AND ELECTRICAL POWER"
1160 PRINT
1170 PRINT"TYPE 'C' & RETURN KEY TO GO ON";
1180 LINE INPUT A$
1190 IF A$="C" THEN 1310
1200 PRINT C$;
1210 PRINT"LOOK "N$" , I DON'T KNOW WHAT"
1220 PRINT"YOUR TROUBLE IS, BUT TYPING IN"
1230 PRINT"THE WRONG ANSWER JUST PROLONGS"
1240 PRINT"THE LESSON"
1250 PRINT" I CAN KEEP GOING IN CIRCLES"
1260 PRINT"ALL DAY BUT THAT WON'T FINISH"
1270 PRINT"THE LESSON.  THIS TIME TRY A"
1280 PRINT"LITTLE HARDER TO FOLLOW THE"
1290 PRINT"STUPID DIRECTIONS, OK?"
1300 GOTO 1170
1310 PRINT C$;
1320 PRINT N$", SINCE YOU MAY ALREADY"
1330 PRINT"KNOW SOME OF THE OBJECTIVES"
1340 PRINT"GIVEN, I'M GOING TO GIVE YOU"
1350 PRINT"A BRIEF PRE-TEST OVER THE"
1360 PRINT"LESSON.  THERE ARE 10 QUESTIONS"
1370 PRINT"IN THE EXAM.  DO THE BEST YOU"
1380 PRINT"CAN.  YOU GET ONLY ONE (1) CHANCE."
1390 PRINT"KEEP TRACK OF THE NUMBER YOU"
1400 PRINT"MISS.  IF YOU MISS MORE THAN"
1410 PRINT"TWO (2), YOU WILL NOT BE ABLE"
1420 PRINT"TO SKIP THE LESSON."
1430 PRINT"(TYPE 'C' & RETURN KEY TO GO ON)";
1440 LINE INPUT A$
1450 IF A$="C" THEN 1470
1460 GOTO 1430
1470 PRINT C$;
1480 PRINT"WHICH OF THE FOLLOWING PHRASES"
1490 PRINT"BEST DEFINES ELECTRICAL POWER?"
1500 PRINT"  1.  TIME RATE AT WHICH WORK IS"
1510 PRINT"      DONE."
1520 PRINT"  2.  MOVING AN OBJECT BY APPLY-
1530 PRINT"      ING FORCE."
1540 PRINT"  3.  CAPACITY TO DO WORK."
```

```
1550 PRINT"  4.  DIFFERENCE IN POTENTIAL."
1560 PRINT
1570 PRINT"TYPE THE NUMBER OF YOUR ANSWER";
1580 C=0
1590 INPUT A
1600 IF A=3 THEN 1630
1610 PRINT"WRONG"
1620 GOTO 1650
1630 PRINT"CORRECT"
1640 C=C+1
1650 PRINT"PUSH THE RETURN KEY TO CONTINUE";
1660 LINE INPUT A$
1670 PRINT C$;
1680 PRINT"WHICH OF THE FOLLOWING BEST"
1690 PRINT"EXPRESSES THE RELATIONSHIP THAT"
1700 PRINT"EXISTS BETWEEN POWER, WORK,"
1710 PRINT"AND TIME?"
1720 PRINT"  1.  P=WORK DIVIDED BY TIME"
1730 PRINT"  2.  P=TIME DIVIDED BY WORK"
1740 PRINT"  3.  P=WORK TIMES TIME"
1750 PRINT"  4.  P=WORK PLUS TIME"
1760 PRINT
1770 PRINT"TYPE THE NUMBER OF YOUR ANSWER"
1780 INPUT A
1790 IF A=3 THEN 1810
1800 PRINT"WRONG" : GOTO 1830
1810 PRINT"CORRECT"
1820 C=C+1
1830 PRINT"PUSH THE RETURN KEY TO CONTINUE";
1840 LINE INPUT A$
1850 PRINT C$;
1860 PRINT"IN WHAT FORM IS POWER USED IN"
1870 PRINT"MOST ELECTRICAL APPLIANCES?"
1880 PRINT"  1.  MOVEMENT OF ELECTRONS"
1890 PRINT"  2.  LIGHT"
1900 PRINT"  3.  HEAT"
1910 PRINT"  4.  FRICTION"
1920 PRINT
1930 PRINT"TYPE IN THE NUMBER OF YOUR ANSWER";
1940 INPUT A
1950 IF A=3 THEN 1980
1960 PRINT"WRONG"
1970 GOTO 2000
1980 PRINT"RIGHT"
1990 C=C+1
2000 PRINT"PUSH RETURN KEY TO CONTINUE";
2010 LINE INPUT A$
2020 PRINT C$;
2030 PRINT"WHAT IS THE UNIT OF MEASURE OF"
2040 PRINT"ELECTRICAL POWER?"
2050 PRINT"  1.  CALORIE"
2060 PRINT"  2.  WATT"
2070 PRINT"  3.  COULOMB"
2080 PRINT"  4.  JOULE"
```

```
2090 PRINT
2100 PRINT"TYPE IN THE NUMBER OF YOUR ANSWER";
2110 INPUT A
2120 IF A=2 THEN 2150
2130 PRINT"WRONG"
2140 GOTO 2170
2150 PRINT"CORRECT"
2160 C=C+1
2170 PRINT"PUSH THE RETURN KEY TO CONTINUE"
2180 LINE INPUT A$
2190 PRINT C$;
2200 PRINT"ELECTRICAL POWER IS A MEASURE"
2210 PRINT"OF ------.?"
2220 PRINT"  1.  POTENTIAL"
2230 PRINT"  2.  TOTAL WORK PERFORMED"
2240 PRINT"  3.  RATE AT WHICH WORK IS DONE"
2250 PRINT"  4.  WASTED WORK"
2260 PRINT
2270 PRINT"TYPE THE NUMBER OF YOUR ANSWER";
2280 INPUT A
2290 IF A=2 THEN 2310
2300 PRINT"WRONG":GOTO 2330
2310 PRINT"CORRECT"
2320 C=C+1
2330 PRINT"PUSH RETURN KEY TO CONTINUE"
2340 LINE INPUT A$
2350 PRINT C$;
2360 PRINT"THE TYPE OF METER USED TO"
2370 PRINT"MEASURE ELECTRICAL POWER"
2380 PRINT"IN A CIRCUIT IS A -----?"
2390 PRINT"  1.  WATTMETER"
2400 PRINT"  2.  VOLTMETER"
2410 PRINT"  3.  AMMETER"
2420 PRINT"  4.  WAVEMETER"
2430 PRINT
2440 PRINT"TYPE THE NUMBER OF YOUR ANSWER";
2450 INPUT A
2460 IF A=1 THEN 2490
2470 PRINT"WRONG"
2480 GOTO 2510
2490 PRINT"CORRECT"
2500 C=C+1
2510 PRINT"PUSH THE RETURN KEY TO GO ON";
2520 LINE INPUT A$
2530 PRINT C$;
2540 PRINT"POWER CAN BE DEFINED AS THE"
2550 PRINT"ABILITY TO DO WORK"
2560 PRINT"  1.  TRUE"
2570 PRINT"  2.  FALSE"
2580 PRINT
2590 PRINT"TYPE THE NUMBER OF YOUR ANSWER";
2600 INPUT A
```

```
2610 IF A=2 THEN 2640
2620 PRINT"WRONG"
2630 GOTO 2660
2640 PRINT"CORRECT"
2650 C=C+1
2660 PRINT"PUSH THE RETURN KEY TO GO ON";
2670 LINE INPUT A$
2680 PRINT C$;
2690 PRINT"THE WORD WATT IS AN ELECTRICAL"
2700 PRINT"TERM THAT -----."
2710 PRINT"  1.  REFERS TO TEMPERATURE
2720 PRINT"      IN A CIRCUIT"
2730 PRINT"  2.  DISTINGUISHES A CONDUCTOR
2740 PRINT"      FROM AN INSULATOR"
2750 PRINT"  3.  INDICATES UNKNOWN QUALITY
2760 PRINT"      IN A CIRCUIT."
2770 PRINT"  4.  IS A UNIT OF ELECTRICAL"
2780 PRINT"      POWER IN A CIRCUIT."
2790 PRINT
2800 PRINT"TYPE THE NUMBER OF YOUR ANSWER";
2810 INPUT A
2820 IF A=4 THEN 2850
2830 PRINT"WRONG"
2840 GOTO 2870
2850 PRINT"CORRECT"
2860 C=C+1
2870 PRINT"PUSH THE RETURN KEY TO CONTINUE";
2880 LINE INPUT A$
2890 PRINT C$;
2900 PRINT"ENERGY POSSESSED BY A BODY IS"
2910 PRINT"FORM OF -----?"
2920 PRINT"  1.  DYNAMIC ENERGY"
2930 PRINT"  2.  KINETIC ENERGY"
2940 PRINT"  3.  ENERGY IN MOTION"
2950 PRINT"  4.  POTENTIAL ENERGY"
2960 PRINT
2970 PRINT"TYPE IN THE NUMBER OF YOUR ANSWER";
2980 INPUT A
2990 IF A=4 THEN 3020
3000 PRINT"WRONG"
3010 GOTO 3040
3020 PRINT"CORRECT"
3030 C=C+1
3040 PRINT"PUSH THE RETURN KEY TO CONTINUE";
3050 LINE INPUT A$
3060 PRINT C$;
3070 PRINT"THE ABILITY TO DO WORK IS CALLED?"
3080 PRINT"  1.  ENERGY"
3090 PRINT"  2.  WORK"
3100 PRINT"  3.  FORCE"
3110 PRINT"  4.  POWER :
3120 PRINT
```

```
3130 PRINT"TYPE THE NUMBER OF YOUR ANSWER";
3140 INPUT A
3150 IF A=1 THEN 3180
3160 PRINT"WRONG"
3170 GOTO 3200
3180 PRINT"CORRECT"
3190 C=C+1
3200 PRINT"PUSH THE RETURN KEY TO CONTINUE";
3210 LINE INPUT A$:PRINT C$;
3220 I=C*100/10
3230 PRINT""N$", YOUR SCORE ON THE PRE-TEST"
3240 PRINT"WAS "C" OR "I"%.  IF YOU MISSED MORE"
3250 PRINT"THAN TWO OF THE 10 QUESTIONS, THEN"
3260 PRINT"YOU MUST TAKE THE LESSON.  TO RECORD"
3270 PRINT"THE SCORE OF YOUR PRETEST, TYPE"
3280 PRINT"'R' AND PUSH THE RETURN KEY."
3290 INPUT R$:PRINT C$;
3300 IF R$="R" THEN 3340
3310 IF R$<> THEN 3320
3320 PRINT"I DON'T KNOW WHAT YOU PUSHED, BUT"
3330 PRINT"IT WASN'T AN 'R'.  TRY AGAIN.":GOTO 3290
3340 LSET Y$ (1)=MKI$(I)
3350 PUT #1,N
3360 IF I>=80 THEN 3380
3370 IF I<80 THEN 3550
3380 PRINT"YOUR SCORE ON THE PRETEST WAS"
3390 PRINT"HIGH ENOUGH TO ALLOW YOU TO SKIP"
3400 PRINT"THE LESSON.  YOU MAY NOW EITHER"
3410 PRINT"TAKE THE LESSON OR THE POST-TEST."
3420 PRINT"TYPE 'A' FOR THE LESSON AND 'B' FOR"
3430 PRINT"THE POST-TEST."
3440 INPUT Z$
3450 IF Z$="A" THEN 3600
3460 IF Z$="B" THEN 3540
3470 PRINT"I DON'T KNOW WHAT YOU PUSHED "N$","
3480 PRINT"BUT IT WASN'T AN 'A' OR A 'B'.  TRY"
3490 PRINT"GAIN.  'A' FOR LESSON, 'B' FOR TEST."
3500 GOTO 3440
3510 PRINT" (PUSH RETURN KEY TO CONTINUE)
3520 GOTO 3600
3530 LINE INPUT A$:PRINT C$;
3540 RUN"ELECPWR3",0
3550 PRINT"I'M SORRY "N$", YOUR SCORE ON THE"
3560 PRINT"PRE-TEST WILL NOT ALLOW YOU TO SKIP"
3570 PRINT"THE LESSON.  PUSH THE RETURN KEY AND"
3580 PRINT"WE WILL GET ON WITH THE LESSON."
3590 LINE INPUT A$:PRINT C$;
3600 PRINT"HOLD ON, I HAVE TO LOAD THE"
3610 PRINT"REST OF THE PROGRAM IN THE"
3620 PRINT"COMPUTER SO WE CAN CONTINUE."
3630 PRINT"IT SHOULD TAKE ME ABOUT 20"
```

```
3640 PRINT"SECONDS OR SO AND THEN WE"
3650 PRINT"CAN BE ON WITH THE LESSON."
3660 LOAD"ELECPWR2",1,R
OK
```

SAMPLE INTERACTIVE LESSON WITH NO MANAGEMENT PROGRAM

```
LOAD"ELEC #17
WORKING...
OK

LIST1-999

5 REM - THIS IS THE FIRST PART OF LESSON
10 REM - $17, D.C. POWER
17 REM - WRITTEN BY D.L. JELDEN - UNC. CODE
19 REM - NUMBER ON DISK IS 'ELEC #17'
20 C$=CHR$(27)+";" : PRINT C$;
25 REM - N=CAI I.D. NUMBER
30 REM - N$=STUDENT ANME (FIRST NAME)
32 REM - S$=SOCIAL SECURITY NUMBER
35 PRINT"PLEASE TYPE IN YOUR FIRST NAME."
40 INPUT N$:PRINT C$;
125 PRINT"           D.C. POWER"
130 PRINT"       LESSON OBJECTIVES"
135 PRINT
140 PRINT"  1.  HOW TO DETERMINE THE POWER"
145 PRINT"USED BY A RESISTOR IN A DIRECT"
150 PRINT"CURRENT CIRCUIT."
155 LINE INPUT A$:PRINT C$;
160 PRINT"  2.  HOW TO DETERMINE THE TOTAL"
165 PRINT"POWER USED IN A DIRECT CURRENT"
170 PRINT"CIRCUIT."
175 LINE INPUT A$:PRINT C$;
180 PRINT"I AM GOING TO GIVE YOU A"
185 PRINT"PRETEST.  THE PURPOSE OF THIS"
190 PRINT"PRETEST IS TO PERMIT YOU TO SKIP"
195 PRINT"THIS LESSON IF YOU ALREADY"
200 PRINT"KNOW THE MATERIAL."
205 LINE INPUT A$:PRINT C$;
210 PRINT"THIS PRETEST COVERS ALL THE"
215 PRINT"ESSENTIAL INFORMATION TAUGHT IN"
220 PRINT"THE LESSON.  DO NOT GUESS OR TAKE"
225 PRINT"TOO MUCH TIME WITH ANY ONE"
230 PRINT"QUESTION."
235 LINE INPUT A$:PRINT C$;
240 PRINT"            PRETEST"
245 PRINT
250 PRINT"  1.  WHICH OF THE FOLLOWING"
255 PRINT"PHRASES BEST DEFINES ELECTRICAL"
260 PRINT"POWER?"
265 PRINT"  A.  TIME RATE AT WHICH WORK IS"
270 PRINT"      DONE"
275 PRINT"  B.  MOVING AN OBJECT BY"
280 PRINT"      APPLYING FORCE"
285 PRINT"  C.  CAPACITY TO DO WORK"
```

```
290 PRINT"  D.  DIFFERENCE OF POTENTIAL"
295 CN=0
300 LINE INPUT A$:PRINT C$;
305 IF A$="A" THEN 315
310 GOTO 320
315 CN=CN+1
320 PRINT"  2.  IN WHAT FORM IS POWER USED"
325 PRINT"BY A RESISTOR?"
330 PRINT"  A.  MOVEMENT OF ELECTRONS"
335 PRINT"  B.  LIGHT"
340 PRINT"  C.  HEAT"
345 PRINT"  D.  FRICTION"
350 LINE INPUT A$:PRINT C$;
355 IF A$="C" THEN 365
360 GOTO 370
365 CN=CN+1
370 PRINT"  3.  WHICH EQUATION SHOWN BELOW"
372 PRINT"WOULD BE USED TO CORRECTLY"
374 PRINT"DETERMINE POWER?"
376 PRINT"  A.  P = E 2R"
378 PRINT"  B.  P = I 2/R
380 PRINT"  C.  P = IR"
382 PRINT"  D.  P = I 2R"
384 LINE INPUT A$:PRINT C$;
386 IF A$="D" THEN 395
390 GOTO 400
395 CN=CN+1
400 PRINT"  4.  A CIRCUIT HAS 6 VOLTS"
402 PRINT"APPLIED AND ONE RESISTOR WITH A"
404 PRINT"VALUE OF 6 OHMS.  IF THE RESISTOR"
406 PRINT"IS REPLACED WITH A 12 OHM"
408 PRINT"RESISTOR, THE POWER USED WILL"
410 PRINT"  A.  DOUBLE"
412 PRINT"  B.  REMAIN THE SAME"
414 PRINT"  C.  DECREASE"
415 LINE INPUT A$:PRINT C$;
420 IF A$="C" THEN 430
425 GOTO 435
430 CN=CN+1
435 PRINT"  5.  WHAT IS THE UNIT OF MEASURE"
440 PRINT"FOR ELECTRICAL POWER?"
445 PRINT"  A.  CALORIE"
446 PRINT"  B.  WATT"
447 PRINT"  C.  COULOMB"
448 PRINT"  D.  JOULE"
449 LINE INPUT A$:PRINT C$;
450 IF A$="B" THEN 460
455 GOTO 465
460 CN=CN+1
465 PRINT"  6.  HOW MUCH POWER IS USED BY A"
466 PRINT"5 OHM RESISTOR WITH 2 AMPERES"
468 PRINT"OF CURRENT FLOWING THROUGH IT?"
```

```
470 PRINT"  A.  2.5 W"
471 PRINT"  B.  7.0 W"
472 PRINT"  C.  10.0 W"
473 PRINT"  D.  20.0 W"
475 LINE INPUT A$:PRINT C$;
480 IF A$="D" THEN 490
485 GOTO 495
490 CN=CN+1
495 PRINT"  7.  HOW MUCH CURRENT FLOWS"
500 PRINT"THROUGH A 60 WATT LIGHT BULB"
502 PRINT"WHEN IT IS CONNECTED TO A 120"
504 PRINT"VOLT OUTLET?"
506 PRINT"  A.  0.5 A"
507 PRINT"  B.  2.0 A"
508 PRINT"  C.  180.0 A"
509 PRINT"  D.  720.0 A"
510 LINE INPUT A$:PRINT C$;
515 IF A$="A" THEN 525
520 GOTO 530
525 CN=CN+1
530 PRINT"  8.  A CIRCUIT HAS 100 VOLTS"
535 PRINT"APPLIED AND A CURRENT OF"
537 PRINT".25 AMPS.  WHAT IS THE TOTAL"
538 PRINT"POWER USED BY THE CIRCUIT?"
540 PRINT"  A.  15 W"
542 PRINT"  B.  20 W"
544 PRINT"  C.  25 W"
546 PRINT"  D.  30 W"
547 LINE INPUT A$:PRINT C$;
550 IF A$="C" THEN 560
555 GOTO 565
560 CN=CN+1
565 PRINT"  9.  WHICH FACTOR BELOW"
570 PRINT"DETERMINES HOW MUCH POWER A"
575 PRINT""RESISTOR IS CAPABLE OF"
577 PRINT"DISSIPATING?"
578 PRINT"  A.  VALUE OF RESISTOR"
579 PRINT"  B.  SURFACE AREA"
580 PRINT"  C.  CURRENT FLOW"
585 PRINT"  D.  SAFETY FACTOR"
587 LINE INPUT A$:PRINT C$;
590 IF A$="B" THEN 600
595 GOTO 605
600 CN=CN+1
605 PRINT"  10.  IN WHAT TWO WAYS ARE"
610 PRINT"RESISTORS GENERALLY RATED?"
615 PRINT"  A.  CURRENT HANDLING ABILITY"
620 PRINT"      AND WATTS"
625 PRINT"  B.  OHMS AND WATTS"
630 PRINT"  C.  VOLTAGE CAPABILITY AND"
635 PRINT"      POWER
640 PRINT"  D.  WATTS AND TOLERANCE"
645 LINE INPUT A$:PRINT C$;
650 IF A$="B" THEN 660
```

```
655 GOTO 825
660 CN=CN+1
825 I=CN*100/10
830 PRINT""N$", YOUR SCORE ON THE PRE-TEST"
835 PRINT"WAS "CN" OR "I"%.  IF YOU MISSED"
840 PRINT"MORE THAN 2 OF THE 10 QUESTIONS"
845 PRINT"THEN YOU MUST TAKE THE LESSON.  TO"
850 PRINT"RECORD THE SCORE OF YOUR PRE-TEST,'
885 PRINT"MARK IT ON THE PROGRESS CHART IN"
890 PRINT"THE SPACE PROVIDED FOR LESSON #17."
895 LINE INPUT A$:PRINT C$;
900 IF I<80 THEN 990
905 PRINT"YOUR SCORE ON THE PRE-TEST WAS"
910 PRINT"HIGH ENOUGH TO ALLOW YOU TO SKIP"
915 PRINT"THE LESSON.  YOU MAY NOW EITHER"
920 PRINT"TAKE THE LESSON OR THE POST-TEST."
925 PRINT"TYPE 'A' FOR THE LESSON AND 'B'"
930 PRINT"FOR THE POST-TEST."
935 INPUT Z$
940 IF Z$="A" THEN 970
945 IF Z$="B" THEN 985
950 PRINT"I DON'T KNOW WHAT WAS PUSHED, BUT"
955 PRINT"IT WASN'T AN 'A' OR 'B'.  'A' FOR"
960 PRINT"THE LESSON AND 'B' FOR THE POST-"
965 PRINT"TEST.  TRY AGAIN.": GOTO 935
970 PRINT"(PUSH THE RETURN KEY TO CONTINUE)."
975 GOTO 1000
980 LINE INPUT A$:PRINT C$;
985 RUN "ELEC#17E",0
990 PRINT"I'M SORRY "N$", YOUR SCORE WILL NOT"
991 PRINT"ALLOW YOU TO SKIP THE LESSON.  PUSH"
992 PRINT"THE RETURN KEY AND WE WILL GET ON"
993 PRINT"WITH IT.";
995 LINE INPUT A$:PRINT C$;
1000 PRINT"POWER IS DEFINED AS:"
1005 PRINT"THE TIME RATE AT WHICH WORK IS"
1010 PRINT"DONE, THE TIME RATE AT WHICH"
1015 PRINT"ENERGY IS USED.  IN AN ELECTRICAL"
1020 PRINT"CIRCUIT THE WORK DONE IS THE"
1025 PRINT"FORCING OF ELECTRONS THROUGH THE"
1030 PRINT"CIRCUIT BY THE APPLIED VOLTAGE."
1035 LINE INPUT A$:PRINT C$;
1040 PRINT"TO UNDERSTAND POWER WE SHOULD"
1045 PRINT"FIRST BECOME FAMILIAR WITH THE"
1050 PRINT"TERM WORK."
1055 PRINT
1060 PRINT"WORK IS PERFORMED ANYTIME AN"
1065 PRINT"OBJECT IS MOVED BY THE"
1070 PRINT"APPLICATION OF A FORCE."
1075 LINE INPUT A$:PRINT C$;
1080 PRINT"IF YOUR CAR WERE TO RUN OUT OF"
1085 PRINT"GAS, YOU WOULD HAVE TO PUSH IT"
1090 PRINT"TO THE SIDE OF THE ROAD."
1095 PRINT"PUSHING THE CAR WOULD BE A FORM"
```

```
1100 PRINT"OF WORK."
1105 PRINT"  A. WORK"
1110 PRINT"  B. FORCE"
1115 PRINT"  C. ENERGY"
1120 PRINT"CHOOSE THE CORRECT ANSWER"
1125 PRINT"AND TYPE A, B, OR C."
1130 LINE INPUT A$:PRINT C$;
1135 IF A$="B" THEN 1150
1137 IF A$="C" THEN 1170
1140 IF A$="A" THEN 1180
1145 GOTO 1190
1150 PRINT"NO.  THE FORCE IS WHAT YOU APPLY"
1155 PRINT"TO THE CAR WHEN YOU PUT YOUR"
1160 PRINT"SHOULDER AGAINST IT AN PUSH."
1165 GOTO 1075
1170 PRINT"WRONG.  THE ENERGY IS YOUR OWN"
1175 PRINT"ABILITY TO PUSH THE CAR."
1177 GOTO 1075
1180 PRINT"WORK. RIGHT, AND THE BIGGER THE"
1185 PRINT"CAR, THE MORE WORK YOU MUST DO."
1187 GOTO 1200
1190 PRINT"TRY THAT ONE AGAIN "N$"."
1195 GOTO 1075
1200 LINE INPUT A$:PRINT C$;
1205 PRINT"WHEN WE CAUSE ELECTRONS TO MOVE"
1210 PRINT"TRHOUGH A CIRCUIT BY APPLYING A"
1215 PRINT"VOLTAGE, --?-- IS BEING DONE."
1220 PRINT"  A.  WORK"
1225 PRINT"  B.  FORCE"
1230 PRINT"  C.  ENERGY
1235 PRINT"CHOOSE THE CORRECT ANSWER"
1240 PRINT"AND TYPE A, B OR C."
1245 LINE INPUT A$:PRINT C$;
1250 IF A$="B" THEN 1280
1255 IF A$="C" THEN 1300
1260 IF A$="A" THEN 1320
1265 GOTO 1340
1280 PRINT"COME ON.  WE'VE ALREADY SAID THAT"
1285 PRINT"FORCE IS A PRESSURE APPLIED TO"
1290 PRINT"AN OBJECT TO MAKE IT MOVE."
1295 GOTO 1200
1300 PRINT"NO, NO.  ONCE AGAIN. THE ENERGY"
1305 PRINT"WOULD BE THE ABILITY OF THE"
1310 PRINT"VOLTAGE TO CAUSE MOVEMENT OF"
1315 PRINT"ELECTRONS."
1317 GOTO 1200
1320 PRINT"WORK. CORRECT.  ANY TIME ANY"
1325 PRINT"OBJECT IS MOVED BY ANY FORCE,"
1330 PRINT"WORK IS PERFORMED."
1335 GOTO 1350
1340 PRINT"TRY THAT ONE AGAIN "N$"."
1345 GOTO 1200
1350 LINE INPUT A$:PRINT C$;
```

```
1355 PRINT"ANOTHER TERM YOU SHOULD BECOME"
1360 PRINT"FAMILIAR WITH IS ENERGY, WHICH"
1365 PRINT"IS DEFINED AS THE ABILITY TO DO"
1370 PRINT"WORK."
1375 PRINT
1380 PRINT"WHEN PUSHING A CAR, YOUR"
1385 PRINT"STRENGTH IS YOUR SOURCE OF ENERGY."
1390 PRINT"THE MORE STRENGTH YOU HAVE, THE"
1395 PRINT"MORE ENERGY, AND THE MORE WORK"
1400 PRINT"YOU CAN DO."
1405 LINE INPUT A$:PRINT C$;
1410 PRINT"ANYTIME ANY KIND OF WORK IS DONE,"
1415 PRINT"ENERGY MUST BE USED TO DO IT."
1420 LINE INPUT A$:PRINT C$;
1425 PRINT"WHEN PUSHING A CAR YOU ARE"
1430 PRINT"PERFORMING WORK AND USING --?--."
1435 PRINT"  A.  FORCE"
1440 PRINT"  B.  ENERGY"
1445 PRINT"  C.  EFFORT"
1450 PRINT"CHOOSE THE CORRECT ANSWER"
1455 PRINT"AND TYPE A, B, OR C."
1460 LINE INPUT A$:PRINT C$;
1465 IF A$="A" THEN 1480
1470 IF A$="C" THEN 1510
1472 IF A$="B" THEN 1520
1475 GOTO 1530
1480 PRINT"THINK NOW.  WHEN PUSHING, YOU ARE"
1485 PRINT"APPLYING THE FORCE, WHICH IS THE"
1490 PRINT"SAME AS SAYING YOU ARE MAKING AN"
1495 PRINT"EFFORT.  IF YOU HAVE THE ABILITY"
1500 PRINT"THE CAR WILL MOVE."
1505 GOTO 1420
1510 PRINT"NO.  YOU DON'T USE EFFORT, YOU"
1515 PRINT"MAKE AND EFFORT."
1517 GOTO 1420
1520 PRINT"ENERGY.  YES YOU ARE.  IF YOU HAVE"
1525 PRINT"NO ENERGY YOU DO NO WORK."
1527 GOTO 1540
1530 PRINT"TRY THAT ONE AGAIN "N$"."
1535 GOTO 1420
1540 LINE INPUT A$:PRINT C$;
1545 PRINT"WHEN WORK IS PERFORMED BY FORCING"
1550 PRINT"ELECTRONS THROUGH A CIRCUIT WITH"
1555 PRINT"AN APPLIED VOLTAGE, --?-- MUST BE"
1560 PRINT"USED."
1565 PRINT"  A.  EFFORT"
1570 PRINT"  B.  FORCE"
1575 PRINT"  C.  ENERGY"
1580 PRINT"CHOOSE THE CORRECT ANSWER"
1585 PRINT"AND TYPE A, B OR C.
1590 LINE INPUT A$:PRINT C$;
1595 IF A$="A" THEN 1610
```

```
1596 IF A$="B" THEN 1620
1597 IF A$="C" THEN 1630
1600 GOGO 1650
1610 PRINT"WRONG.  THE EFORT IS WHAT THE"
1615 PRINT"BATTERY WOULD BE EXERTING, OR"
1617 PRINT"TRYING TO DO."
1619 GOTO 1540
1620 PRINT"WRONG.  THE FORCE WOULD BE THE"
1625 PRINT"PRESSURE APPLIED IN THE FORM OF"
1626 PRINT"VOLTAGE.": GOTO 1540
1630 PRINT"ENERGY.  THAT'S RIGHT.  WHENEVER"
1635 PRINT"WORK IS DONE, ENERGY MUST BE USED."
1640 GOTO 1660
1650 PRINT"TRY THAT ONE AGAIN "N$"."
1655 GOTO 1540
1660 LINE INPUT A$:PRINT C$;
1665 PRINT"YOU CAN EASILY SEE THAT WORK"
1670 PRINT"DONE AND ENERGY REQUIRED TO DO"
1675 PRINT"THAT WORK, ARE VERY CLOSELY"
1680 PRINT"RELATED."
1685 PRINT
1690 PRINT"ALTHOUGH POWER IS USUALLY"
1695 PRINT"REFERRED TO AS THE TIME RATE AT"
1700 PRINT"WHICH WORK IS DONE, IT MAY ALSO"
1705 PRINT"BE CALLED THE TIME ARE AT WHICH"
1710 PRINT"ENERGY IS USED."
1715 LINE INPUT A$:PRINT C$;
1720 PRINT"THE TIME RATE AT WHICH WORK IS"
1725 PRINT"DONE, OR, THE TIME RATE AT WHICH"
1730 PRINT"ENERGY IS USED IN AN ELECTRICAL"
1735 PRINT"CIRCUIT, IS CALLED --?--."
1740 PRINT"  A.  CURRENT"
1745 PRINT"  B.  POWER"
1750 PRINT"  C.  FORCE"
1755 PRINT"CHOOSE THE CORRECT ANSWER"
1760 PRINT"AND TYPE A, B OR C."
1765 LINE INPUT A$:PRINT C$;
1770 IF A$="A" THEN 1790
1775 IF A$="C" THEN 1810
1777 IF A$="B" THEN 1830
1780 GOTO 1850
1790 PRINT"YOU'VE GOT TO BE KIDDING."
1795 PRINT"CURRENT IS THE FLOW OF ELECTRONS"
1800 PRINT"THROUGH A CIRCUIT."
1805 GOTO 1715
1810 PRINT"WRONG.  A FORCE IS APPLIED TO AN"
1815 PRINT"OBJECT TO MAKE IT MOVE.  THEN WE"
1820 PRINT"HAVE WORK BEING PERFORMED."
1825 GOTO 1715
1830 PRINT"POWER.  OK.  NOW WE KNOW THAT POWER"
1835 PRINT"IS JUST AN INDICATION OF HOW"
1840 PRINT"MUCH WORK IS BEING DONE IN A"
```

```
1845 PRINT"CIRCUIT.  LET'S GO ON."
1847 GOTO 1860
1850 PRINT"TRY THAT ONE AGAIN "N$"."
1955 GOTO 1715
1860 LINE INPUT A$:PRINT C$;
1865 PRINT"TO FOR CE A CURRENT THROUGH A"
1870 PRINT"CIRCUIT, A CERTAIN AMOUNT OF"
1875 PRINT"ENERGY MUST BE USED."
1880 PRINT"THE MOUNT OF ENERGY THAT WE USE."
1885 PRINT"KNOWN AS POWER, IS MEASURED IN"
1890 PRINT"UNITS CALLED WATTS."
1895 LINE INPUT A$:PRINT C$;
1900 PRINT"JUST AS VOLTAGE, CURRENT AND"
1905 PRINT"RESISTANCE HAVE UNITS OF MEASURE,"
1910 PRINT"THERE IS A UNIT OF MEASURE FOR"
1915 PRINT"THE POWER USED BY A CIRCUIT OR"
1920 PRINT"COMPONENT."
1925 PRINT"THIS UNIT IS CALLED A 'WATT'."
1930 LINE INPUT A$:PRINT C$;
1935 PRINT"HOLD ON A SEC PARD AND I'LL ROUND"
1940 PRINT"UP THE REST OF THIS LESSON."
1945 RUN "ELEC#17A",0
OK


LOAD"ELEC#17A
WORKING...
OK


LIST

1950 REM - THIS IS PART 'A' OF LESSON
1955 REM - #17, D.C. POWER, WRITTEN BY
1957 REM - D.L. Jelden - UNC. CODE NUMBER
1958 REM - ON DISK IS 'ELEC#17A'
1960 C$=CHR$(27)+";": PRINT C$;
1965 PRINT"THE LETTER DESIGNATION FOR POWER"
1970 PRINT"IS 'P', AND FOR WATTS IT IS 'W'."
1975 LINE INPUT A$:PRINT C$;
1980 PRINT"THE WATT IS THE UNIT OF"
1985 PRINT"MEASUREMENT REPRESENTING"
1990 PRINT"  A.  POWER"
1995 PRINT"  B.  WORK"
2000 PRINT"  C.  ENERGY"
2005 PRINT"CHOOSE THE CORRECT ANSWER"
2010 PRINT"AND TYPE A, B OR C."
2015 LINE INPUT A$:PRINT C$;
2020 IF A$="B" THEN 2050
2025 IF A$="C" THEN 2070
2030 IF A$="A" THEN 2090
2035 GOTO 2100
2050 PRINT"I'M AFRAID NOT.  THERE ARE OTHER"
```

```
2055 PRINT"UNITS OF MEASURE FOR WORK.  WE"
2060 PRINT"ARE NOT INTERESTED IN THEM NOW."
2065 GOTO 1975
2070 PRINT"NO.  THERE IS ANOTHER UNIT OF"
2075 PRINT"MEASURE FOR ENERGY.  REMEMBER"
2080 PRINT"WATT YOU'RE LOOKING FOR."
2085 GOTO 1975
2090 PRINT"POWER.  RIGHT.  EASY, WASN'T IT?"
2095 GOTO 2110
2100 PRINT"TRY THAT AGAIN "N$"."
2105 GOTO 1975
2110 LINE INPUT A$:PRINT C$;
2115 PRINT"THE TIME RATE AT WHICH WORK IS"
2120 PRINT"DONE IN AN ELECTRICAL CRICUIT IS"
2125 PRINT"MEASURED IN"
2130 PRINT"  A.  POWER"
2135 PRINT"  B.  ENERGY"
2140 PRINT"  C.  WATTS"
2145 PRINT"CHOOSE THE CORRECT ANSWER"
2150 PRINT"AND TYPE A, B OR C."
2155 LINE INPUT A$:PRINT C$;
2160 IF A$="A" THEN 2180
2165 IF A$="B" THEN 2200
2170 IF A$="C" THEN 2230
2175 GOTO 2250
2180 PRINT"SHAME ON YOU.  POWER IS THE TIME"
2185 PRINT"RATE AT WHICH WORK IS DONE."
2190 GOTO 2110
2200 PRINT"INCORRECT.  ENERGY IS WHAT WE ARE"
2205 PRINT"USING WHEN WE DO THE WORK."
2210 PRINT"ENERGY USED AND WORK DONE ARE"
2215 PRINT"PRACTICALLY THE SAME AS FAR AS"
2220 PRINT"OUR UNIT OF MEASURE IS CONCERNED."
2225 GOTO 2110
2230 PRINT"WATTS.  RIGHT.  THE TIME RATE AT"
2235 PRINT"WHICH WORK IS DONE IN A CIRCUIT"
2240 PRINT"IS POWER AND IT IS MEASURED IN"
2245 PRINT"WATTS."
2247 GOTO 2260
2250 PRINT"TRY THAT AGAIN "N$"."
2255 GOTO 2110
2260 LINE INPUT A$:PRINT C$;
2265 PRINT"THERE IS A DIRECT RELATIONSHIP"
2270 PRINT"BETWEEN POWER, VOLTAGE AND"
2275 PRINT"CURRENT."
2280 LINE INPUT A$:PRINT C$;
2285 PRINT"THIS MEANS THAT IF VOLTAGE, OR"
2290 PRINT"CURRENT, INCREASES, POWER WILL"
2295 PRINT"ALSO INCREASE.  IF VOLTAGE OR"
2300 PRINT"CURRENT DECREASES, POWER WILL"
2305 PRINT"DECRASE."
2310 LINE INPUT A$:PRINT C$;
```

```
2315 PRINT"WE KNOW THAT WORK IS THE MOVEMENT"
2320 PRINT"OF AN OBJECT BY THE APPLICATION"
2325 PRINT"OF A FORCE."
2330 LINE INPUT A$:PRINT C$;
2335 PRINT"IT SEEMS REASONABLE TO SAY THAT"
2340 PRINT"IF MORE FORCE IS APPLIED, MORE"
2345 PRINT"WORK IS DONE.  ON THE OTHER HAND,"
2350 PRINT"IF A BIGGER OBJECT OR MORE"
2355 PRINT"OBJECTS ARE MOVED, MORE WORK IS"
2360 PRINT"BEING DONE."
2365 LINE INPUT A$:PRINT C$;
2370 PRINT"IN A CIRCUIT, THE VOLTAGE IS OUR"
2375 PRINT"FORCE, SO IF IT INCREASES, THE"
2380 PRINT"AMOUNT OF WORK DONE, WHICH IS"
2385 PRINT"OUR POWER, WILL ALSO INCREASE."
2390 LINE INPUT A$:PRINT C$;
2395 PRINT"SHOULD THE CURRENT, WHICH IS THE"
2400 PRINT"NUMBER OF OBJECTS BEING MOVED,"
2405 PRINT"INCREASE, THEN THE WORK BEING"
2410 PRINT"DONE, OR POWER, MUST AGAIN"
2415 PRINT"INCREASE."
2420 LINE INPUT A$:PRINT C$;
2425 PRINT"IF EITHER VOLTAGE OR CURRENT IN"
2430 PRINT"A CIRCUIT IS DECREASED, THE"
2435 PRINT"POWER IN THE CIRCUIT WILL --?--."
2440 PRINT"  A.  INCREASE"
2445 PRINT"  B.  REMAIN THE SAME"
2450 PRINT"  C.  DECREASE"
2455 PRINT"CHOOSE THE CORRECT ANSWER"
2460 PRINT"AND TYPE A, B OR C."
2465 LINE INPUT A$:PRINT C$;
2470 IF A$="A" THEN 2490
2475 IF A$="B" THEN 2530
2477 IF A$="C" THEN 2550
2480 GOTO 2580
2490 PRINT"NO.  IF VOLTAGE DOES DOWN, IT"
2495 PRINT"MEANS LESS FORCE APPLIED.  IF"
2500 PRINT"CURRENT LESSENS, IT MEANS THE
2505 PRINT"OBJECT BEING MOVED IS SMALLER."
2510 PRINT"BOTH CASES INDICATE LESS WORK"
2515 PRINT"BEING DONE."
2517 GOTO 2420
2520 PRINT"REMEMBER THAT THE AMOUNT OF"
2525 PRINT"POWER DEPENDS ON THE AMOUNT OF"
2530 PRINT"FORCE AND THE SIZE, OR NUMBER,"
2535 PRINT"OF THE OBJECTS BEING MOVED."
2540 GOTO 2420
2550 PRINT"DECREASE.  THAT'S RIGHT.  LESS"
2555 PRINT"VOLTAGE, LESS PUSHING FORCE."
2560 PRINT"LESS CURRENT, FEWER OBJECTS"
2565 PRINT"BEING MOVED.  IN BOTH CASES THERE"
2570 PRINT"IS LESS WORK BEING DONE."
2575 GOTO 2590
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2580 PRINT"TRY THAT ONE AGAIN "N$"."
2585 GOTO 2420
2590 LINE INPUT A$:PRINT C$;
2595 PRINT"THIS SHOWS A DIRECT RELATIONSHIP"
2600 PRINT"BETWEEN THE THREE, WHICH MEANS"
2605 PRINT"THAT THE VALUE OF POWER WILL"
2607 PRINT"'E' OR 'I' WENT UP, 'P' WOULD"
2610 PRINT"INCREASE AS A RESULT OF AN"
2615 PRINT"INCREASE IN CURRENT OR VOLTAGE,"
2620 PRINT
2625 PRINT"AND WILL DECREASE AS A RESULT OF"
2630 PRINT"A DECREASE IN CURRENT OR VOLTAGE."
2635 LINE INPUT A$:PRINT C$;
2640 PRINT"THE RELATIONSHIP BETWEEN POWER,"
2645 PRINT"VOLTAGE AND CURRENT IS"
2650 PRINT"  A.  AN INVERSE ONE"
2655 PRINT"  B.  A DIRECT ONE"
2660 PRINT"  C.  AN INDIRECT ONE"
2665 PRINT"CHOOSE THE CORRECT ANSWER"
2670 PRINT"AND TYPE A, B OR C."
2675 LINE INPUT A$:PRINT C$;
2680 IF A$="A" THEN 2700
2685 IF A$="C" THEN 2720
2690 IF A$="B" THEN 2740
2695 GOTO 2750
2700 PRINT"NO.  INVERSE MEANS OPPOSITE OR"
2705 PRINT"REVERSE.  THIS WOULD MEAN THAT IF"
2710 PRINT"'E' OR 'I' WENT UP, 'P' WOULD"
2715 PRINT"GO DOWN."
2717 GOTO 2635
2720 PRINT"NO. AN INDIRECT RELATIONSHIP"
2725 PRINT"WOULD BE JUST THE OPPOSITE OF"
2730 PRINT"THE ONE BETWEEN POWER, VOLTAGE"
2735 PRINT"AND CURRENT."
2737 GOTO 2635
2740 PRINT"A DIRECT ONE.  YOU BET YOUR SWEET"
2745 PRINT"BIPPY IT IS.": GOTO 2760
2750 PRINT"TRY THAT ONE AGAIN."
2755 GOTO 2635
2760 LINE INPUT A$:PRINT C$;
2765 PRINT"IF THE APPLIED VOLTAGE TO A"
2770 PRINT"CIRCUIT IS CHANGED FROM 6 VOLTS"
2775 PRINT"TO 12 VOLTS, THE POWER CONSUMED"
2780 PRINT"BY THE CIRCUIT WILL"
2785 PRINT"  A.  INCREASE"
2790 PRINT"  B.  DECREASE"
2795 PRINT"  C.  NOT CHANGE"
2800 PRINT"CHOOSE THE CORRECT ANSWER"
2805 PRINT"AND TYPE A, B OR C."
2810 LINE INPUT A$:PRINT C$;
2815 IF A$="B" THEN 2830
2820 IF A$="C" THEN 2840
2825 IF A$="A" THEN 2860
2827 GOTO 2880
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2830 PRINT"SHAME ON YOU.  IF VOLTAGE"
2832 PRINT"INCREASE WHAT HAPPENS TO POWER?"
2835 GOTO 2760
2840 PRINT"WRONG.  IF VOLTAGE OR CURRENT"
2845 PRINT"CHANGES, POWER WILL DEFINITELY"
2847 PRINT"CHANGE."
2850 GOTO 2760
2860 PRINT"INCREASE.  GOOD.  IT'S THE SAME AS"
2865 PRINT"IF YOU HAD 2 MEN PUSHING A CAR"
2870 PRINT"INSTEAD OF 1.  MORE WORK WOULD"
2875 PRINT"GET DONE.": GOTO 2890
2880 PRINT"TRY THAT ONE AGAIN "N$"."
2885 GOTO 2760
2890 LINE INPUT A$:PRINT C$;
2895 PRINT"RESISTANCE AND POWER IN A"
2900 PRINT"CIRCUIT ALSO HAVE A CERTAIN"
2905 PRINT"RELATIONSHIP."
2910 LINE INPUT A$:PRINT C$;
2915 PRINT"HOWEVER, IN THIS CASE, THE"
2920 PRINT"RELATIONSHIP IS AN INVERSE ONE,"
2925 PRINT"MEANING THAT IF RESISTANCE"
2930 PRINT"INCREASES, POWER DECREASES"
2935 PRINT
2940 PRINT"AND IF RESISTANCE DECREASES,"
2945 PRINT"POWER WILL INCREASE."
2950 LINE INPUT A$:PRINT C$;
2955 PRINT"YOU ALREADY KNOW THAT IF VOLTAGE"
2960 PRINT"OR CURRENT INCREASES, THE POWER"
2965 PRINT"WILL INCREASE."
2970 LINE INPUT A$:PRINT C$;
2975 PRINT"FROM THIS YOU SHOULD EASILY BE"
2980 PRINT"ABLE TO DETERMINE WHAT HAPPENS"
2985 PRINT"IF RESISTANCE IN A CIRCUIT VARIES."
2990 LINE INPUT A$:PRINT C$;
2995 PRINT"IF RESISTANCE SHOULD INCREASE,"
3000 PRINT"IT CAUSES CURRENT TO DECREASE,"
3005 PRINT"WHICH IN TURN CAUSES POWER TO"
3010 PRINT"  A.  INCREASE"
3015 PRINT"  B.  DECREASE"
3020 PRINT"  C.  REMAINS THE SAME"
3025 PRINT"CHOOSE THE CORRECT ANSWER"
3030 PRINT"AND TYPE A, B OR C."
3035 LINE INPUT A$:PRINT C$;
3040 IF A$="A" THEN 3060
3045 IF AR="C" THEN 3080
3050 IF A$="B" THEN 3100
3055 GOTO 3120
3066 PRINT"NO, NO, NO.  WE JUST SAID THAT IF"
3067 PRINT"'R' GOES UP, 'I' GOES DOWN.  WHAT"
3070 PRINT"EFFECT DOES THAT HAVE ON 'P'?"
3075 GOTO 2990
3080 PRINT"ANY CHANGE IN 'E' OR 'I' CAUSES A"
3085 PRINT"CHANGE IN 'P', RIGHT?  ANY CHANGE"
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3095 PRINT"FIGURE IT OUT FROM THERE."
3097 GOTO 2990
3100 PRINT"DECREASE.  GOOD.  IF AN INCREASE"
3105 PRINT"IN RESISTANCE CAUSES CURRENT TO"
3110 PRINT"DECREASE, IT ALSO CAUSES POWER"
3115 PRINT"TO DECREASE."
3117 GOTO 3130
3120 PRINT"TRY THAT ONE AGAIN "N$"."
3125 GOTO 2990
3130 LINE INPUT A$:PRINT C$;
3135 PRINT"IF A POTENTIOMETER IS CHANGED"
3140 PRINT"FROM 150K OHMS TO 100K OHMS, THE"
3145 PRINT"POWER CONSUMED BY IT WOULD"
3150 PRINT"  A.  DECREASE"
3155 PRINT"  B.  NOT CHANGE"
3160 PRINT"  C.  INCREASE"
3165 PRINT"CHOOSE THE CORRECT ANSWER"
3170 PRINT"AND TYPE A, B OR C."
3175 LINE INPUT A$:PRINT C$;
3180 IF A$="A" THEN 3200
3185 IF A$="B" THEN 3250
3190 IF A$="C" THEN 3250
3195 GOTO 3260
3200 PRINT"COME ON, RECALL OHM'S LAW.  IF 'R'"
3205 PRINT"GOES DOWN, WHAT HAPPENS TO I?"
3210 PRINT"AND IF 'I' GOES UP OR DOWN, WHAT"
3215 PRINT"HAPPENS TO 'P'?"
3220 GOTO 3130
3230 PRINT"YOU'RE WRONG.  IT WILL CHANGE."
3235 PRINT"ANY CHANGE IN 'R' CAUSES A CHANGE"
3240 PRINT"IN 'I' AND ANY CHANGE IN 'I'"
3245 PRINT"CAUSES A CHANGE IN 'P'."
3247 GOTO 3130
3250 PRINT"INCREASE.  RIGHT.  IF 'R' GOES"
3255 PRINT"DOWN, 'P' GOES UP."
3257 GOTO 3270
3260 PRINT"TRY THAT ONE AGAIN "N$"."
3265 GOTO 3130
3270 LINE INPUT A$:PRINT C$;
3275 PRINT"YOU NOW KNOW THAT IF RESISTANCE"
3280 PRINT"INCREASES, POWER DECREASES AND"
3285 PRINT"IF IT DECREASES, POWER INCREASES."
3290 PRINT"THIS IS KNOWN AS AN INVERSE"
3295 PRINT"RELATIONSHIP."
3300 LINE INPUT A$:PRINT C$;
3306 PRINT"IF A RESISTOR IN A CIRCUIT WERE"
3310 PRINT"TO INCREASE IN VALUE, THE POWER"
3315 PRINT"CONSUMED BY THAT RESISTOR WOULD"
3320 PRINT"  A.  GO UP"
3325 PRINT"  B.  GO DOWN"
3330 PRINT"  C.  NOT CHANGE"
3335 PRINT"CHOOSE THE CORRECT ANSWER"
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3340 PRINT"AND TYPE A, B OR C."
3345 LINE INPUT A$:PRINT C$;
3350 IF A$="A" THEN 3370
3355 IF A$="C" THEN 3390
3360 IF A$="B" THEN 3410
3365 GOTO 3440
3370 PRINT"NEVER HAPPEN.  THE ONLY WAY POWER"
3375 PRINT"WILL GO UP IS TO HAVE AN INCREASE"
3380 PRINT"IN VOLTAGE OR CURRENT."
3385 GOTO 3300
3390 PRINT"INCORRECT.  REMEMBER THAT ANY"
3395 PRINT"CHANGE IN 'E', 'I' OR 'R' WILL
3400 PRINT"CAUSE A CHANGE IN 'P'."
3405 GOTO 3300
3410 PRINT"GO DOWN.  CORRECT.  THAT'S WHATN AN"
3415 PRINT"INVERSE RELATIONSHIP IS ALL ABOUT."
3420 PRINT"WHEN ONE VALUE RISES, IT CAUSES"
3425 PRINT"THE OTHER TO DROP.  IF IT DROPS,"
3430 PRINT"THE OTHER RISES."
3435 GOTO 3450
3440 PRINT"TRY THAT ONE AGAIN, PAL."
3445 GOTO 3300
3450 LINE INPUT A$:PRINT C$;
3455 PRINT"THE RELATIONSHIP OF POWER TO"
3460 PRINT"VOLTAGE AND CURRENT IS BEST"
3465 PRINT"EXPRESSED BY THE FORMULA:"
3470 PRINT"POWER = VOLTAGE TIMES CURRENT."
3475 LINE INPUT A$:PRINT C$;
3480 PRINT"HANG ON THERE PARTNER AND THIS"
3485 PRINT"SHOW WILL 'REALLY' GET ON THE"
3490 PRINT"ROAD."
3495 RUN "ELEC#17B",0
OK


LOAD"ELEC#17B
WORKING...
OK


LIST

3500 REM - THIS IS PART 'B' OF LESSON
3505 REM - #17, D.C. POWER, WRITTEN BY
3510 REM - D.L. JELDEN - UNC. CODE
3515 REM - NUMBER ON DISK IS 'ELEC#17B'
3517 C$=CHR$(27)+";": PRINT C$;
3520 PRINT"IN ORDER TO DETERMINE THE POWER"
3525 PRINT"CONSUMED BY A CIRCUIT OR A"
3530 PRINT"COMPONENT, WE MUST DETERMINE THE"
3535 PRINT"AMOUNT OF WORK BEING DONE."
3540 LINE INPUT A$:PRINT C$;
3545 PRINT"THE WAY WE DO THIS IS TO"
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3550 PRINT"MULTIPLY VOLTAGE, WHICH IS THE"
3555 PRINT"MOVING FORCE, BY CURRENT, WHICH"
3560 PRINT"IS THE OBJECT BEING MOVED."
3565 LINE INPUT A$:PRINT C$;
3570 PRINT"EXPRESSED AS A FORMULA, THIS IS:"
3575 PRINT"POWER EQUALS CURRENT TIMES"
3580 PRINT"VOLTAGE."
3585 LINE INPUT A$:PRINT C$;
3590 PRINT"TO SIMPLIFY IT FURTHER FOR POWER"
3595 PRINT"CALCULATIONS, WE EXPRESS IT AS"
3600 PRINT"AN EQUATION.  THIS EQUATION IS"
3605 PRINT"P=IE."
3610 PRINT"IN THE EQUATION 'P' IS POWER IN"
3615 PRINT"WATTS 'I' IS CURRENT IN AMPS, AND"
3620 PRINT"'E' IS VOLTAGE IN VOLTS."
3625 LINE INPUT A$:PRINT C$;
3630 PRINT"TO DETERMINE THE POWER CONSUMED"
3635 PRINT"BY A CIRCUIT OR A COMPONENT WE"
3640 PRINT"MUST --?--."
3645 PRINT"  A.  MULTIPLY"
3650 PRINT"  B.  ADD"
3655 PRINT"  C.  DIVIDE"
3660 PRINT"CHOOSE THE CORRECT ANSWER"
3665 PRINT"AND TYPE A, B OR C."
3670 LINE INPUT A$:PRINT C$;
3675 IF A$="B" THEN 3700
3680 IF A$="C" THEN 3710
3685 IF A$="A" THEN 3720
3690 GOTO 3730
3700 PRINT"POWER IS A DIRECT PRODUCT OF"
3705 PRINT"VOLTAGE AND CURRENT."
3707 GOTO 3625
3710 PRINT"NO.  P=IE DOESN'T INDICATE ANY"
3715 PRINT"DIVISION WHATSOEVER, YET."
3717 GOTO 3625
3720 PRINT"MULTIPLY.  RIGHT 'I' TIMES 'E'"
3725 PRINT"EQUALS 'P'."
3727 GOTO 3740
3730 PRINT"WHAT WAS THAT AGAIN "N$"?"
3735 GOTO 3625
3740 LINE INPUT A$:PRINT C$;
3745 PRINT"THERE IS A MAGIC CIRCLE FOR THIS"
3750 PRINT"EQUATION JUST AS THERE IS FOR"
3755 PRINT"OHM'S LAW.  IT IS SHOWN ON THE"
3760 PRINT"CHART LOCATED AT THE TERMINAL"
3765 PRINT"OR IN FIGURE 170.  COPY IT."
3770 LINE INPUT A$:PRINT C$;
3775 PRINT"IF TWO OF THE VALUES SHOWN IN"
3780 PRINT"THE CIRCLE ARE KNOWN, YOU CAN"
3785 PRINT"FIND THE THIRD BY COVERING THE"
3790 PRINT"UNKNOWN AND COMPLETING THE"
3795 PRINT"MATHEMATICAL FUNCTION USING THE"
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3800 PRINT"KNOWN VALUES."
3805 LINE INPUT A$:PRINT C$;
3810 PRINT"IF POWER AND VOLTAGE ARE KNOWN,"
3815 PRINT"CURRENT CAN BE FOUND BY DIVIDING"
3820 PRINT"--?--."
3825 PRINT"  A.  POWER INTO VOLTAGE"
3830 PRINT"  B.  VOLTAGE INTO POWER"
3835 PRINT"  C.  VOLTAGE BY POWER"
3840 PRINT"CHOOSE THE CORRECT ANSWER"
3845 PRINT"AND TYPE A, B OR C."
3850 LINE INPUT A$:PRINT C$;
3855 IF A$="A" THEN 3880
3860 IF A$="C" THEN 3900
3865 IF A$="B" THEN 3930
3870 GOTO 3950
3880 PRINT"WRONG.  LOOK AT THE CIRCLE.  COVER"
3885 PRINT"'I'.  WHICH IS WHAT WE WANT TO"
3890 PRINT"FIND.  WHAT IS LEFT?  TAKE IT FROM"
3895 PRINT"THERE."
3897 GOTO 3805
3900 PRINT"WRONG.  LOOK AT THE CIRCLE.  COVER"
3905 PRINT"'I', WHICH IS WHAT WE WANT TO"
3910 PRINT"KNOW.  P/E IS LEFT.  WHAT DOES"
3915 PRINT"THAT INDICATE?"
3920 GOTO 3805
3930 PRINT"VOLTAGE INTO POWER.  THAT'S"
3935 PRINT"RIGHT.  USE THE CIRCLE JUST AS"
3940 PRINT"YOU DID THE ONE FROM OHM'S LAW."
3945 GOTO 3960
3950 PRINT"TRY THAT ONE AGAIN "N$"."
3955 GOTO 3805
3960 LINE INPUT A$:PRINT C$;
3965 PRINT"IF POWER AND CURRENT ARE KNOWN,"
3970 PRINT"VOLTAGE CAN BE FOUND BY --?--."
3975 PRINT"  A.  DIVIDNG CURRENT INTO"
3980 PRINT"      VOLTAGE"
3985 PRINT"  B.  DIVIDING CURRENT INTO POWER"
3990 PRINT"  C.  DIVIDING CURRENT BY POWER"
3995 PRINT"CHOOSE THE CORRECT ANSWER"
4000 PRINT"AND TYPE A, B OR C."
4005 LINE INPUT A$:PRINT C$;
4010 IF A$="A" THEN 4030
4015 IF A$="C" THEN 4050
4020 IF A$="B" THEN 4070
4025 GOTO 4090
4030 PRINT"NO.  USE THE CIRCLE THE SAME WAY"
4035 PRINT"YOU DID TO FIND 'I', EXCEPT IN"
4040 PRINT"THIS CASE COVER THE 'E'."
4045 GOTO 3960
4050 PRINT"NOT SO.  LOOK AT THE"
4055 PRINT"CIRCLE.  YOU DID SOMETHING"
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4060 PRINT"BACKWARDS, DIDN'T YOU?"
4065 GOTO 3960
4070 PRINT"DIVIDING CURRENT INTO POWER."
4075 PRINT"VERY GOOD."
4080 GOTO 4100
4090 PRINT"TRY THAT ONE AGAIN "N$"."
4095 GOTO 3960
4100 LINE INPUT A$:PRINT C$;
4105 PRINT"IF A RESISTOR HAS 3A OF CURRENT"
4110 PRINT"FLOWING THROUGH IT AND IS"
4115 PRINT"DISSIPATING 18W, THE VOLTAGE"
4120 PRINT"DROP ACROSS THE RESISTOR IS --?--."
4125 PRINT"  A.  54V"
4130 PRINT"  B.  21V"
4135 PRINT"  C.  6 V"
4140 PRINT"CHOOSE THE CORRECT ANSWER"
4145 PRINT"AND TYPE A, B OR C."
4150 LINE INPUT A$:PRINT C$;
4155 IF A$="A" THEN 4180
4160 IF A$="B" THEN 4200
4165 IF A$="C" THEN 4220
4170 GOTO 4240
4180 PRINT"TAKE ANOTHER LOOK AT YOUR CIRCLE."
4185 PRINT"SEE WHERE IT SAY TO MULTIPLY"
4190 PRINT"'P' AND 'I'."
4195 GOTO 4100
4200 PRINT"WRONG.  NO ADDITION OR SUBTRACTION"
4205 PRINT"IS INDICATED BY THE MAGIC CIRCLE."
4210 GOTO 4100
4220 PRINT"6V.  THAT'S THE WAY.  YOU'RE"
4225 PRINT"MOVING RIGHT ALONG NOW."
4230 GOTO 4250
4240 PRINT"TRY THAT ONE AGAIN "N$"."
4245 GOTO 4100
4250 LINE INPUT A$:PRINT C$;
4255 PRINT"A SECOND EQUATION CAN BE DERIVED"
4260 PRINT"FROM P=IE SIMPLY BY SUBSTITUTING"
4265 PRINT"FROM OHM'S LAW."
4270 PRINT"SINCE E=IR, WE CAN REPLACE 'E'"
4275 PRINT"IN THE EQUATION, WITH 'IR' AND"
4280 PRINT"HAVE E=I SQUARED R"
4285 LINE INPUT A$:PRINT C$;
4290 PRINT"THE EQUATION P=IE MAY AT TIMES"
4295 PRINT"NOT FILL OUR NEEDS FOR"
4300 PRINT"CALCULATIONS INVOLVING POWER."
4305 LINE INPUT A$:PRINT C$;
4310 PRINT"AN EXAMPLE WOULD BE A CASE OF"
4315 PRINT"KNOWING POWER AND RESISTANCE,"
4320 PRINT"AND SEEKING THE VALUE OF CURRENT."
4325 PRINT
4330 PRINT"TO SOLVE THIS PARTICULAR TYPE OF"
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4335 PRINT"PROBLEM, WE MODIFY OUR ORIGINAL"
4340 PRINT"EQUATION BY SUBSTITUTING FROM"
4345 PRINT"OHM'S LAW."
4350 LINE INPUT A$:PRINT C$;
4355 PRINT"WHEN USING P=I SQUARED R TO"
4360 PRINT"DETERMINE POWER, YOUR FIRST STEP"
4365 PRINT"WOULD BE TO CONVERT ANY VALUE"
4370 PRINT"WITH A PREFIX TO BASIC UNITS."
4375 LINE INPUT A$:PRINT C$;
4380 PRINT"YOUR NEXT STEP SHOULD BE TO --?--."
4385 PRINT"  A.  FIND THE SQUARE ROOT OF"
4390 PRINT"      CURRENT"
4395 PRINT"  B.  MULTIPLY CURRENT BY 2"
4400 PRINT"  C.  MULTIPLY CURRENT BY ITSELF"
4405 PRINT"CHOOSE THE CORRECT ANSWER"
4410 PRINT"AND TYPE A, B OR C."
4415 LINE INPUT A$:PRINT C$;
4420 IF A$="A" THEN 4450
4425 IF A$="B" THEN 4480
4430 IF A$="C" THEN 4500
4435 GOTO 4510
4450 PRINT"NO.  WHEN YOU SEE ANY VALUE WITH"
4455 PRINT"A 2 TO ITS UPPER RIGHT, THIS"
4460 PRINT"MEANS TO SQUARE THE VALUE, OR,"
4465 PRINT"MULTIPLY IT BY ITSELF."
4470 GOTO 4350
4480 PRINT"NO.  IF CURRENT WERE TO BE"
4485 PRINT"MULTIPLIED BY 2 IT WOULD BE"
4490 PRINT"SHOWN IN THIS MANNER"  2I.  I2"
4495 PRINT"MEANS 'I' TIMES 'I'."
4497 GOTO 4350
4500 PRINT"MULTIPLY CURRENT BY ITSELF."
4505 PRINT"GOOD GOING.": GOTO 4520
4510 PRINT"TRY THAT ONE AGAIN "N$"."
4515 GOTO 4350
4520 LINE INPUT A$:PRINT C$;
4525 PRINT"WHEN USING P=I SQUARED R, YOUR"
4530 PRINT"FIRST STEP IS TO SQUARE 'I'.  THEN,"
4535 PRINT"THAT ANSWER IS --?--."
4540 PRINT"  A.  MULTIPLIED BY RESISTANCE"
4545 PRINT"  B.  DIVIDED BY RESISTANCE"
4550 PRINT"  C.  DIVIDED INTO RESISTANCE"
4555 PRINT"CHOOSE THE CORRECT ANSWER"
4560 PRINT"AND TYPE A, B OR C."
4565 LINE INPUT A$:PRINT C$;
4570 IF A$="B" THEN 4590
4575 IF A$="C" THEN 4610
4580 IF A$="A" THEN 4630
4585 GOTO 4650
4590 PRINT"'I' SQUARED 'R' DOES NOT"
4595 PRINT"INDICATE DIVISION.  YOU ARE WRONG,"
4600 PRINT"WRONG, WRONG."
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4605 GOTO 4520
4610 PRINT"WRONG.  'I' SQUARED 'R' TELLS US"
4615 PRINT"TO SQUARE 'I' AND THEN MULTIPLY"
4620 PRINT"BY 'R'."
4625 GOTO 4520
4630 PRINT"MULTIPLIED BY RESISTANCE.  RIGHT."
4635 PRINT"KEEP UP THE GOOD WORK."
4640 GOTO 4660
4650 PRINT"TRY THAT ONE AGAIN "N$"."
4655 GOTO 4520
4660 LINE INPUT A$:PRINT C$;
4665 PRINT"LOOK AT FIGURE 170 IN YOUR"
4670 PRINT"DIAGRAM BOOK.  THERE IS A MAGIC"
4675 PRINT"CIRCLE FOR P=I SQUARED R."
4680 PRINT"COPY IT."
4685 LINE INPUT A$:PRINT C$;
4690 PRINT"JUST AS WITH THE CIRCLE FOR P=IE,"
4695 PRINT"WE CAN ACTUALLY DERIVE TWO OTHER"
4700 PRINT"EQUATIONS FROM THIS ONE."
4705 LINE INPUT A$:PRINT C$;
4710 PRINT"IF WE KNOW 'I' AND 'P' WE CAN"
4715 PRINT"COVER 'R' AND SEE THAT 'P'"
4720 PRINT"DIVIDED BY 'I' SQUARED WILL GIVE"
4725 PRINT"US THE VALUE FOR 'R'."
4730 LINE INPUT A$:PRINT C$;
4735 PRINT"IF 'R' AND 'P' ARE KNOWN, YOU"
4740 PRINT"COVER 'I SQUARED' AND SEE THAT"
4745 PRINT"'P' DIVIDED BY 'R' WILL GIVE AN"
4750 PRINT"EQUAL TO 'I' SQUARED."
4755 LINE INPUT A$:PRINT C$;
4760 PRINT"IF A RESISTOR HAS 3 AMPS OF"
4765 PRINT"CURRENT FLOWING THROUGH IT, AND"
4770 PRINT"IS DISSIPATING 36 WATTS OF"
4775 PRINT"POWER, THE VALUE OF THE RESISTOR"
4780 PRINT"IS --?--."
4785 PRINT"  A.  108 OHMS"
4790 PRINT"  B.  12 OHMS"
4795 PRINT"  C.  4 OHMS"
4800 PRINT"CHOOSE THE CORRECT ANSWER"
4804 PRINT"AND TYPE A, B OR C."
4810 LINE INPUT A$:PRINT C$;
4815 IF A$="A" THEN 4830
4820 IF A$="B" THEN 4860
4825 IF A$="C" THEN 4890
4827 GOTO 4920
4830 PRINT"WRONG.  YOU DO NOT MULTIPLY POWER"
4835 PRINT"BY CURRENT TO FIND RESISTANCE."
4840 PRINT"TAKE A LOOK ARE YOUR CIRCLE AND"
4845 PRINT"DO IT CORRECTLY."
4850 GOTO 4755
4860 PRINT"NOT QUITE, "N$".  YOU DID DIVIDE"
4865 PRINT"'P' BY 'I', BUT YOU FORGOT ONE"
4870 PRINT"VERY IMPORTANT STEP.  CHECK YOUR"
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4875 PRINT"MAGIC CIRCLE AND TRY AGAIN."
4880 GOTO 4755
4890 PRINT"4 OHMS.  THAT'S RIGHT.  THE MAGIC"
4895 PRINT"CIRCLE SHOWS US THAT IF WE"
4900 PRINT"SQUARE THE 3 AMPS AND DIVIDE IT"
4905 PRINT"INTO 36 WATTS WE HAVE 4 OHMS OF"
4910 PRINT"RESISTANCE."
4915 GOTO 4930
4920 PRINT"TRY THAT ONE AGAIN "N$"."
4925 GOTO 4755
4930 LINE INPUT A$:PRINT C$;
4935 PRINT"WE CAN DERIVE STILL ANOTHER"
4940 PRINT"EQUATION FROM P=IE BY"
4945 PRINT"SUBSTITUTING FROM OHM'S LAW."
4950 PRINT"REPLACING 'I' WITH E/R GIVES US"
4955 PRINT"'P' = E SQUARED DIVIDED BY 'R'."
4960 LINE INPUT A$:PRINT C$;
4965 PRINT"WE ALREADY HAVE TWO EQUATIONS"
4970 PRINT"FOR DETERMINING POWER.  HOWEVER,"
4975 PRINT"NEITHER ONE WOULD BE OF ANY USE"
4980 PRINT"IF WE KNEW 'P' AND 'R' AND WANTED"
4985 PRINT"TO FINE 'E', WOULD IT?"
4990 LINE INPUT A$:PRINT C$;
4995 PRINT"WE WILL SUBSTITUTE FROM OHM'S"
5000 PRINT"LAW ONCE AGAIN AND DERIVE A"
5005 PRINT"THIRD EQUATION."
5010 LINE INPUT A$:PRINT C$;
5015 PRINT"LOOKING AT OUR EQUATION, 'P'='E"
5020 PRINT"SQUARED' DIVIDED BY 'R', WE SEE"
5025 PRINT"THAT TO CALCULATE FOR"
5030 PRINT"WATTAGE WE MUST FIRST SQUARE"
5035 PRINT"THE VALUE OF --?--."
5040 PRINT"  A.  RESISTANCE"
5045 PRINT"  B.  VOLTAGE"
5050 PRINT"  C.  POWER"
5055 PRINT"CHOOSE THE CORRECT ANSWER"
5060 PRINT"AND TYPE A, B OR C."
5065 LINE INPUT A$:PRINT C$;
5070 IF A$="A" THEN 5090
5075 IF A$="C" THEN 5110
5080 IF A$="B" THEN 5130
5085 GOTO 5140
5090 PRINT"WRONG.  'R' DOES NOT HAVE A SIGN"
5095 PRINT"TELLING US TO SQUARE IT.  IT'S"
5100 PRINT"JUST SITTING THERE, ALL ALONE."
5105 GOTO 5010
5110 PRINT"DEFINITELY NOT.  'P' HAS NO SQUARE"
5115 PRINT"SIGN THAT I CAN SEE."
5120 GOTO 5010
5130 PRINT"VOLTAGE, CORRECT."
5135 GOTO 5150
5140 PRINT"TRY THAT ONE AGAIN "N$"."
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5145 GOTO 5010
5150 LINE INPUT A$:PRINT C$;
5155 PRINT"I'LL BE BACK IN A FLASH TO"
5160 PRINT"CONTINUE ALL THIS MIND STIMULATION."
5165 RUN "ELEC#17C",0
OK


LOAD"ELEC#17C
WORKING...
OK


LIST

5170 REM - THIS IS PART 'C' OF LESSON
5175 REM - #17, DC POWER, WRITTEN BY D.L.
5180 REM - JELDEN - UNC.  CODE NUMBER ON
5185 REM - DISK IS 'ELEC#17C"
5190 C$=CHR$(27)+";": PRINT C$;
5195 PRINT"ONCE WE HAVE SQUARED THE VOLTAGE,"
5200 PRINT"WE TAKE THE ANSWER AND --?--."
5205 PRINT"  A.  DIVIDE IT BY 'R'"
5210 PRINT"  B.  MULTIPLY IT BY 'R'"
5215 PRINT"  C.  DIVIDE IT INTO 'R'"
5220 PRINT"CHOOSE THE CORRECT ANSWER"
5225 PRINT"AND TYPE A, B OR C."
5230 LINE INPUT A$:PRINT C$;
5235 IF A$="B" THEN 5260
5240 IF A$="C" THEN 5290
5245 IF A$="A" THEN 5310
5250 GOTO 5330
5260 PRINT"NO, NO, NO.  LOOK AT THE EQUATION."
5265 PRINT"COVER 'P', WHICH IS WHAT WE ARE"
5270 PRINT"TRYING TO FIND.  NOW, E SQUARED"
5275 PRINT"'R' IS SHOWING.  AFTER YOU SQUARE"
5277 PRINT"'E', WHAT DOES IT TELL YOU?  TRY"
5280 PRINT"AGAIN."
5285 LINE INPUT A$:PRINT C$;: GOTO 5195
5290 PRINT"STOP KIDDING.  LOOK AT THE"
5295 PRINT"EQUATION.  IT DOESN'T SAY TO"
5297 PRINT"DIVIDE IN THAT MANNER."
5300 LINE INPUT A$:PRINT C$;: GOTO 5195
5310 PRINT"DIVIDE IT BY 'R'.  WE SURE DO.  JUST"
5315 PRINT"LIKE THE EQUATION SHOWS US."
5317 GOTO 5340
5330 PRINT"TRY THAT ONE AGAIN "N$"."
5335 GOTO 5300
5340 LINE INPUT A$:PRINT C$;
5345 PRINT"AS WITH THE OTHER EQUATIONS, WE"
5350 PRINT"ALSO HAVE A MAGIC CIRCLE FOR"
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5355 PRINT"THIS ONE.  FROM IT, WE ARE ABLE"
5360 PRINT"TO DERIVE YET 2 OTHER EQUATIONS"
5365 PRINT"TO AID US IN SOLVING POWER"
5370 PRINT"PROBLEMS.  COPY THE MAGIC CIRCLE,"
5380 LINE INPUT A$:PRINT C$;
5385 PRINT"ONCE AGAIN, IF WE KNOW ANY 2 OF"
5390 PRINT"THE VALUES SHOWN ON THE CIRCLE,'
5395 PRINT"WE COVER THE UNKNOWN, AND"
5400 PRINT"PERFORM THE MATH INVOLVED TO"
5405 PRINT"DETERMINE THE UNKNOWN VALUE."
5410 LINE INPUT A$:PRINT C$;
5415 PRINT"TO FIND VOLTAGE WHEN POWER AND"
5420 PRINT"RESISTANCE ARE KNOWN, THE TWO"
5425 PRINT"ARE FIRST MULTIPLIED.  YOU THEN"
5430 PRINT"TAKE THAT ANSWER AND --?--."
5435 PRINT"  A.  SQUARE IT"
5440 PRINT"  B.  FIND THE SQUARE ROOT OF IT"
5445 PRINT"  C.  DIVIDE IT BY 2"
5450 PRINT"CHOOSE THE CORRECT ANSWER"
5455 PRINT"AND TYPE A, B OR C."
5460 LINE INPUT A$:PRINT C$;
5465 IF A$="A" THEN 5490
5470 IF A$="C" THEN 5520
5475 IF A$="B" THEN 5540
5480 GOTO 5550
5490 PRINT"NO.  WHEN 'P' AND 'R' ARE"
5495 PRINT"MULTIPLIED, THIS GIVES YOU"
5500 PRINT"VOLTAGE, ALREADY SQUARED.  THEN"
5505 PRINT"YOU MUST FIND A NUMBER WHICH,"
5510 PRINT"WHEN MULTIPLIED BY ITSELF, WILL"
5515 PRINT"EQUAL THAT ANSWER."
5517 GOTO 5410
5520 PRINT"WRONG.  'E SQUARED' DOES NOT MEAN"
5525 PRINT"MULTIPLY 'E' BY 2.  IT MEANS 'E'"
5530 PRINT"MULTIPLIED BY ITSELF."
5535 GOTO 5410
5540 PRINT"FIND THE SQUARE ROOT OF IT."
5545 PRINT"VERY GOOD."
5547 GOTO 5560
5550 PRINT"TRY THAT ONE AGAIN "N$"."
5555 GOTO 5410
5560 LINE INPUT A$:PRINT C$;
5565 PRINT"IF A 16 OHM RESISTOR DISSIPATES"
5570 PRINT"4 WATTS OF POWER, WHAT IS THE"
5575 PRINT"VOLTAGE DROP ACROSS THE RESISTOR?"
5580 PRINT"  A.  4 VOLTS"
5585 PRINT"  B.  8 VOLTS"
5590 PRINT"  C.  64 VOLTS"
5595 PRINT"CHOOSE THE CORRECT ANSWER"
5600 PRINT"AND TYPE A, B OR C."
5605 LINE INPUT A$:PRINT C$;
5610 IF A$="A" THEN 5630
5615 IF A$="C" THEN 5650
5620 IF A$="B" THEN 5680
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5625 GOTO 5700
5630 PRINT"TAKE ANOTHER LOOK AT THE MAGIC"
5635 PRINT"CIRCLE.  YOU DIVIDED 'R' INTO 'R'"
5640 PRINT"WHICH IS INCORRECT."
5645 GOT 5560
5650 PRINT"YOU STOPPED TOO SOON.  WHEN YOU"
5655 PRINT"MULTIPLY 'P' TIMES 'R', THIS GIVES"
5660 PRINT"YOU THE VALUE OF 'E' SQUARED."
5665 GOTO 5560
5680 PRINT"8 VOLTS.  RIGHT.  YOU ARE DOING"
5685 PRINT"FIND.  MAKE SURE TO KEEP THOSE"
5690 PRINT"EQUATIONS AND CIRCLES FRESH IN"
5695 PRINT"YOUR MIND AND YOU'LL HAVE NO"
5696 PRINT"TROUBLE WITH POWER PROBLEMS."
5697 GOTO 5710
5700 PRINT"TRY THAT ONE AGAIN "N$"."
5705 GOTO 5560
5710 LINE INPUT A$:PRINT C$;
5715 PRINT"IN ANY TYPE CIRCUIT, THE"
5720 PRINT"INDIVIDUAL POWERS ARE ADDITIVE"
5725 PRINT"AND WILL EQUAL THE TOTAL POWER"
5730 PRINT"OF THE CIRCUIT."
5735 LINE INPUT A$:PRINT C$;
5740 PRINT"THE EQUATION EXPRESSING THIS IS:"
5745 PRINT"PT = P1 + P2 + P3...ETC."
5750 LINE INPUT A$:PRINT C$;
5755 PRINT"IN EVERY TYPE CIRCUIT, THE AMOUNT"
5760 PRINT"OF POWER USED, KNOWN AS TOTAL"
5765 PRINT"POWER -TP-, IS AN INDICATION OF"
5770 PRINT"THE AMOUNT OF WORK DONE IN THE"
5775 PRINT"ENTIRE CIRCUIT."
5780 LINE INPUT A$:PRINT C$;
5785 PRINT"IN SOME CASES WE CAN DETERMINE"
5790 PRINT"'PT' SIMPLY BY MULTIPLYING --?--."
5795 PRINT"  A.  'IT' AND 'RT'"
5800 PRINT"  B.  'RT' AND 'ET'"
5805 PRINT"  C.  'ET' AND 'IT'"
5810 PRINT"CHOOSE THE CORRECT ANSWER"
5815 PRINT"AND TYPE A, B OR C."
5820 LINE INPUT A$:PRINT C$;
5825 IF A$="A" THEN 5850
5830 IF A$="B" THEN 5870
5835 IF A$="C" THEN 5890
5840 GOTO 5910
5850 PRINT"WAKE UP.  IF YOU MULTIPLY 'IT'"
5855 PRINT"AND 'RT', YOU GET 'ET'."
5860 GOTO 5780
5870 PRINT"WRONG.  MULTIPLYING 'E' AND 'R'"
5875 PRINT"GIVES AN ANSWER REPRESENTING"
5880 PRINT"ABSOLUTELY NOTHING IN ELECTRONICS."
5885 GOTO 5780
5890 PRINT"'ET' AND 'IT'.  RIGHT.  WHEN USING"
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5895 PRINT"ANY OF THESE TWO FORMULAS TO FIND"
5900 PRINT"'PT', WE MUST USE THE TOTAL"
5905 PRINT"VALUES OF OUR 2 KNOWN FIGURES."
5907 GOTO 5920
5910 PRINT"TRY THAT ONE AGAIN "N$"."
5915 GOTO 5780
5920 LINE INPUT A$:PRINT C$;
5925 PRINT"A PORTION OF THE TOTAL POWER"
5930 PRINT"WILL BE USED BY EACH RESISTOR,"
5935 PRINT"THE AMOUNT DEPENDING ON THE"
5940 PRINT"CURRENT THROUGH THE RESISTOR AND"
5945 PRINT"THE VOLTAGE DROP ACROSS IT."
5950 LINE INPUT A$:PRINT C$;
5955 PRINT"THEREFORE, WE CAN READILY SEE"
5960 PRINT"THAT IF WE ADD THE POWER USED BY"
5965 PRINT"EACH INDIVIDUAL RESISTOR IN A"
5970 PRINT"CIRCUIT, THE SUM WILL EQUAL 'PT'."
5975 LINE INPUT A$:PRINT C$;
5980 PRINT"THIS WILL BE TRUE IN ANY TYPE OF"
5985 PRINT"CIRCUIT, AND THE FORMULA"
5990 PRINT"EXPRESSING IT IS:"
5995 PRINT"PT = P1 + P2 + P3...ETC."
6000 LINE INPUT A$:PRINT C$;
6005 PRINT"IF 'ET' AND 'IT' ARE UNKNOWN, WE"
6010 PRINT"CAN FIND 'PT' BY TAKING THE POWER"
6015 PRINT"USED BY EACH RESISTOR IN THE"
6020 PRINT"CIRCUIT AND --?-- THEM."
6025 PRINT"  A.  ADDING
6030 PRINT"  B.  AVERAGING"
6035 PRINT"  C.  MULTIPLYING"
6040 PRINT"CHOOSE THE CORRECT ANSWER"
6045 PRINT"AND TYPE A, B OR C."
6050 LINE INPUT A$:PRINT C$;
6055 IF A$="B" THEN 6080
6060 IF A$="C" THEN 6080
6065 IF A$="A" THEN 6110
6070 GOTO 6130
6080 PRINT"YE GADS, NO.  A THOUSAND TIMES,"
6085 PRINT"NO.  THE SUM OF THE POWER USED BY"
6090 PRINT"EACH INDIVIDUAL RESISTOR IS"
6095 PRINT"EQUAL TO THE TOTAL POWER USED BY"
6100 PRINT"THE CIRCUIT."
6105 GOTO 6000
6110 PRINT"ADDING THEM.  THAT IS CORRECT."
6115 PRINT"IT'S JUST A MATTER OF MANY"
6120 PRINT"PORTIONS MAKING UP A WHOLE."
6125 GOTO 6140
6130 PRINT"TRY THAT ONE AGAIN "N$"."
6135 GOTO 6000
6140 LINE INPUT A$:PRINT C$;
6145 PRINT"RESISTORS ARE RATED IN WATTS AS"
6150 PRINT"WELL AS IN OHMS.  THE WATTAGE"
6155 PRINT"RATING INDICATES HOW MUCH POWER"
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6160 PRINT"A RESISTOR CAN SAFELY DISSIPATE"
6165 PRINT"WITHOUT BURNING UP."
6170 LINE INPUT A$:PRINT C$;
6175 PRINT"THE LARGER THE SURFACE AREA OF A"
6180 PRINT"RESISTOR, THE MORE HEAT IT CAN"
6185 PRINT"DISSIPATE AND THE HIGHER ITS"
6190 PRINT"POWER RATING."
6195 LINE INPUT A$:PRINT C$;
6200 PRINT"WE ALREADY KNOW THAT WHEN CURRENT"
6205 PRINT"FLOWS THROUCH ELECTRICAL"
6210 PRINT"EQUIPMENT A CERTAIN AMOUNT OF"
6215 PRINT"POWER IS CONSUMED."
6220 LINE INPUT A$:PRINT C$;
6225 PRINT"THIS POWER IS DISSIPATED (USED"
6230 PRINT"UP) COMPLETELY IN THE FORM OF"
6335 PRINT"HEAT, MUCH LIKE YOUR OWN BODY,"
6340 PRINT"WHICH BECOMES WARM WHENEVER YOU"
6345 PRINT"DO ANY HARD WORK."
6350 LINE INPUT A$:PRINT C$;
6355 PRINT"WHENEVER ENERGY IS USED IN A"
6360 PRINT"CIRCUIT, IT IS DISSIPATED IN THE"
6365 PRINT"FORM OF --?--."
6370 PRINT"  A.  VOLTAGE"
6375 PRINT"  B.  CURRENT"
6380 PRINT"  C.  HEAT"
6385 PRINT"CHOOSE THE CORRECT ANSWER"
6390 PRINT"AND TYPE A, B OR C."
6395 LINE INPUT A$:PRINT C$;
6400 IF A$="A" THEN 6420
6405 IF A$="B" THEN 6420
6410 IF A$="C" THEN 6430
6415 GOTO 6440
6420 PRINT"HEY, THAT'S FUNNY.  NOW POINT TO"
6425 PRINT"THE RIGHT ANSWER."
6427 GOTO 6350
6430 PRINT"HEAT.  CORRECT."
6435 GOTO 6450
6440 PRINT"TRY THAT ONE AGAIN "N$"."
6445 GOTO 6350
6450 LINE INPUT A$:PRINT C$;
6455 PRINT"IF A RESISTOR CONSUMES A VERY"
6460 PRINT"GREAT AMOUNT OF POWER AND CANNOT"
6465 PRINT"RELEASE THE HEAT FAST ENOUGH, IT"
6470 PRINT"WILL EVENTUALLY BECOME SO HOT"
6475 PRINT"THAT IT WILL BURN UP."
6480 LINE INPUT A$:PRINT C$;
6485 PRINT"DUE TO THIS FACT, RESISTORS ARE"
6490 PRINT"RATED IN WATTS AS WELL AS IN"
6495 PRINT"OHMS."
6500 PRINT
6506 PRINT"THE WATTAGE RATING IS DETERMINED"
6510 PRINT"BY THE SURFACE AREA OF THE"
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6515 PRINT"RESISTOR.  THE LARGER THE SURFACE"
6520 PRINT"AREA THE MORE HEAT IT CAN"
6525 PRINT"RELEASE AND THE LARGER ITS POWER"
6530 PRINT"RATING WILL BE."
6535 LINE INPUT A$:PRINT C$;
6540 PRINT"IF YOU HAVE TWO RESISTORS OF THE"
6545 PRINT"SAME LENGTH BUT OF DIFFERENT"
6550 PRINT"DIAMETERS, WHICH WOULD HAVE THE"
6555 PRINT"LARGER WATTAGE RATING?"
6560 PRINT"  A.  THE SMALLER DIAMETER"
6565 PRINT"  B.  THE LARGER DIAMETER"
6570 PRINT"  C.  BOTH WILL BE THE SAME"
6576 PRINT"CHOOSE THE CORRECT ANSWER"
6580 PRINT"AND TYPE A, B OR C."
6585 LINE INPUT A$:PRINT C$;
6590 IF A$="A" THEN 6620
6595 IF A$="C" THEN 6640
6597 IF A$="B" THEN 6660
6600 GOTO 6690
6620 PRINT"NO.  A SMALLER DIAMETER RESISTOR"
6625 PRINT"WILL HAVE LESS SURFACE AREA THAN"
6630 PRINT"A LARGE DIAMETER ONE."
6635 GOTO 6535
6640 PRINT"THEY CAN'T BOTH BE THE SAME.  THE"
6645 PRINT"AMOUNT OF SURFACE AREA IS"
6650 PRINT"DIFFERENT."
6655 GOTO 6535
6660 PRINT"THE LARGER DIAMETER.  THAT'S"
6665 PRINT"RIGHT.  A LARGER DIAMETER GIVES"
6670 PRINT"MORE SURFACE AREA WHICH MEANS IT"
6675 PRINT"CAN DISSIPATE MORE HEAT."
6680 GOTO 6700
6690 PRINT"TRY THAT ONE AGAIN "N$"."
6695 GOTO 6535
6700 LINE INPUT A$:PRINT C$;
6705 PRINT"DON'T LOSE YOUR SHIRT "N$", I'LL"
6710 PRINT"BE BACK IN A SECOND."
6715 RUN "ELEC#17D",0
OK


LOAD"ELEC#17D
WORKING...
OK


LIST

6720 REM - THIS IS PART'D' OF LESSON
6725 REM - #17, DC POWER, WRITTEN BY D.L.
6730 REM - JELDEN - UNC.  CODE NUMBER ON
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6732 REM - DISK IS 'ELEC#17D'
6735 C$=CHR$(27)+";": PRINT C$;
6740 PRINT"SINCE THE AMOUNT OF POWER"
6745 PRINT"CONSUMED BY A RESISTOR DEPENDS"
6750 PRINT"ON THE AMOUNT OF CURRENT PASSING"
6755 PRINT"THROUGH IT, (P=I SQUARED R), WE"
6760 PRINT"SOMETIMES REFER TO THE POWER"
6765 PRINT"RATING OF A RESISTOR AS AN"
6770 PRINT"INDICATION OF ITS CURRENT"
6775 PRINT"HANDLING ABILITY."
6780 LINE INPUT A$:PRINT C$;
6785 PRINT"THE LARGER THE SURFACE AREA OF A"
6790 PRINT"RESISTOR, THE LARGER WILL BE ITS"
6795 PRINT"--?--."
6800 PRINT"  A.  TOLERANCE"
6806 PRINT"  B.  SAFETY FACTOR"
6810 PRINT"  C.  POWER RATING"
6815 PRINT"CHOOSE THE CORRECT ANSWER"
6820 PRINT"AND TYPE A, B OR C."
6825 LINE INPUT A$:PRINT C$;
6830 IF A$="A" THEN 6850
6835 IF A$="B" THEN 6880
6840 IF A$="C" THEN 6900
6845 GOTO 6930
6850 PRINT"NO.  TOLERANCE IS A DEVIATION"
6855 PRINT"FROM A RATED VALUE AND IS"
6860 PRINT"ASSIGNED TO A RESISTOR RATHER"
6865 PRINT"THAN BUILT I."
6870 GOTO 6780
6880 PRINT"WRONG.  A SAFETY FACTOR IS A"
6885 PRINT"SAFETY MEASURE, AND WE WILL"
6890 PRINT"LEARN ABOUT IT VERY SHORTLY."
6895 GOTO 6780
6900 PRINT"POWER RATING.  GOOD.  REMEMBER"
6905 PRINT"THE POWER RATING DEPENDS ON"
6910 PRINT"SURFACE AREA, AND SURFACE AREA"
6915 PRINT"DEPENDS ON DIAMETER AND LENGTH."
6920 GOTO 6940
6930 PRINT"TRY THAT ONE AGAIN "N$"."
6935 GOTO 6780
6940 LINE INPUT A$:PRINT C$;
6945 PRINT"IN ELECTRONIC EQUIPMENT, YOU"
6950 PRINT"WILL USE RESISTORS WHICH HAVE A"
6955 PRINT"POWER RATING 2 TO 4 TIMES AS"
6960 PRINT"GREAT AS THE POWER WHICH WILL BE"
6965 PRINT"CONSUMED BY THE RESISTOR DURING"
6970 PRINT"NORMAL USE."
6975 PRINT
6980 PRINT"THIS IS A SAFETY MEASURE AND IS"
6985 PRINT"REFERRED TO AS A SAFETY FACTOR"
6990 PRINT"OF 2 - 4."
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6996 LINE INPUT A$:PRINT C$;
7000 PRINT"IN SOME CASES YOU WILL BE"
7005 PRINT"WORKING WITH PIECES OF EQUIPMENT"
7010 PRINT"SO COMPACT THAT THE RESISTORS IN"
7015 PRINT"IT WILL BE CLOSELY PACKED AND"
7020 PRINT"ALMOST TOUCHING ONE ANOTHER."
7025 PRINT
7030 PRINT"THIS MAKES IT DIFFICULT FOR THEM"
7035 PRINT"TO DISSIPATE HEAT."
7040 LINE INPUT A$:PRINT C$;
7045 PRINT"TO PROTECT A RESISTOR FROM"
7050 PRINT"BURNING UP BECAUSE OF THIS, WE"
7055 PRINT"USE A SAFETY FACTOR OF 2 TO 4."
7060 LINE INPUT A$:PRINT C$;
7065 PRINT"THIS MEANS THAT IF A RESISTOR"
7070 PRINT"NORMALLY CONSUMES 2 WATTS OF"
7075 PRINT"POWER, WE USE A RESISTOR WITH A"
7080 PRINT"4 - 8 WATT RATING."
7085 LINE INPUT A$:PRINT C$;
7090 PRINT"THIS IS DONE MERELY AS A SAFETY"
7095 PRINT"PRECAUTION."
7100 LINE INPUT A$:PRINT C$;
7105 PRINT"IF YOU ARE REPLACING A RESISTOR"
7110 PRINT"IN A CIRCUIT AND HAVE DETERMINED"
7115 PRINT"THAT IT WILL HAVE TO DISSIPATE"
7120 PRINT"1/2 WATT OF POWER, WHAT WOULD"
7125 PRINT"BE THE WATTAGE RATING OF THE"
7130 PRINT"RESISTOR YOU INSTALL, IF YOU WANT"
7135 PRINT"A SAFETY FACTOR OF 4?"
7140 PRINT"  A.  1/2 WATT"
7145 PRINT"  B.  2 WATTS"
7150 PRINT"  C.  4 WATTS"
7155 PRINT"CHOOSE THE CORRECT ANSWER"
7160 PRINT"AND TYPE A, B OR C."
7165 LINE INPUT A$:PRINT C$;
7170 IF A$="A" THEN 7190
7175 IF A$="C" THEN 7230
7180 IF A$="B" THEN 7250
7185 GOTO 7270
7190 PRINT"NOW, READ CAREFULLY:  THE RESISTOR"
7195 PRINT"WILL NORMALLY DISSIPATE 1/2 W."
7200 PRINT"USING THE SAFETY FACTOR OF 4"
7205 PRINT"MEANS TO USE A RESISTOR RATED 4"
7210 PRINT"TIMES THAT SIZE,  YOU WERE WRONG."
7215 PRINT"TRY AGAIN."
7220 GOTO 7100
7230 PRINT"WE DON'T NEED ONE THAT LARGE."
7235 PRINT"THE SAFETY FACTOR OF 4 IS ONLY A"
7240 PRINT"MULTIPLIER."
7245 GOTO 7100
7250 PRINT"CERTAINLY, BECAUSE 2 IS FOUR"
7255 PRINT"TIME AS GREAT AS 1/2."
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7260 GOTO 7280
7270 PRINT"TRY THAT ONE AGAIN "N$"."
7275 GOTO 7100
7280 LINE INPUT A$:PRINT C$;
7285 PRINT"COMPOSITION RESISTORS NORMALLY"
7290 PRINT"COME IN ONE OF FIVE SIZES.  THESE"
7295 PRINT"ARE:  1/8W, 1/4W, 1/2W, 1W AND"
7300 PRINT"2W RATINGS."
7305 LINE INPUT A$:PRINT C$;
7310 PRINT"RESISTORS WITH WATTAGE RATINGS"
7315 PRINT"GREATER THAN 2 WATTS WILL"
7320 PRINT"USUALLY BE WIRE WOUND."
7325 LINE INPUT A$:PRINT C$;
7330 PRINT"YOU WILL RARELY WORK WITH"
7335 PRINT"RESISTORS RATED ABOUT 2 WATTS"
7340 PRINT"THIS IS ESPECIALLY TRUE IN SOLID"
7345 PRINT"STATE AND IC CIRCUITS."
7350 LINE INPUT A$:PRINT C$;
7355 PRINT"A 50K OHM RESISTOR IN A CIRCUIT"
7360 PRINT"HAS 1MA OF CURRENT FLOWING"
7365 PRINT"THROUGH IT.  THE SMALLEST WATTAGE"
7370 PRINT"RATED RESISTOR WE CAN USE,"
7375 PRINT"OBSERVING A SAFETY FACTOR OF 4,"
7380 PRINT"IS"
7385 PRINT"  A.  1/8 WATT"
7390 PRINT"  B.  1/4 WATT"
7395 PRINT"  C.  1/2 WATT"
7400 PRINT"CHOOSE THE CORRECT ANSWER"
7405 PRINT"AND TYPE A, B OR C."
7410 LINE INPUT A$:PRINT C$;
7415 IF A$="A" THEN 7430
7420 IF A$="C" THEN 7460
7425 IF A$="B" THEN 7490
7427 GOTO 7510
7430 PRINT"SORRY, THAT'S WRONG, FIRST, FIND"
7435 PRINT"THE POWER CONSUMED AND WORK FROM"
7440 PRINT"THERE.  REFER TO YOUR MAGIC"
7445 PRINT"CIRCLES TO FIND POWER."
7450 GOTO 7350
7460 PRINT"WRONG.  YOU MUST REFER TO YOUR"
7465 PRINT"MAGIC CIRCLE FIRST TO FIND THE"
7470 PRINT"POWER USED BY THE RESISTOR.  THEN"
7475 PRINT"APPLY THE SAFETY FACTOR."
7480 GOTO 7350
7490 PRINT"1/4 WATT.  VERY GOOD.  YOU"
7495 PRINT"REMEMBERED THAT P=I SQUARED R"
7500 PRINT"AS WELL AS THE SAFETY FACTOR"
7505 PRINT"OF FOUR."
7597 GOTO 7520
7510 PRINT"TRY THAT ONE AGAIN "N$"."
7515 GOTO 7350
7520 LINE INPUT A$:PRINT C$;
7525 PRINT"WHEN COMPUTING POWER FOR VARIOUS"
7530 PRINT"COMPONENTS YOU HAVE TO PUT"
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7535 PRINT"TO USE YOUR KNOWLEDGE OF OHM'S"
7540 PRINT"LAW AND OF CIRCUIT ANALYSIS."
7545 LINE INPUT A$:PRINT C$;
7550 PRINT"REMEMBER THE CHARACTERISTICS OF"
7555 PRINT"'E', 'I' AND 'R' IN EACH TYPE"
7560 PRINT"OF CIRCUIT, AND ALSO, THAT YOU"
7565 PRINT"MUST CONVERT ALL VALUES WITH A"
7570 PRINT"PREFIX TO BASIC UNITS."
7575 LINE INPUT A$:PRINT C$;
7580 PRINT"HERE IS A BRIEF SUMMARY OF THE"
7585 PRINT"DC POWER LESSON."
7590 PRINT"  1.  POWER IS THE TIME RATE AT"
7595 PRINT"WHICH WORK IS DONE OR ENERGY IS"
7600 PRINT"USED."
7605 PRINT"  2.  POWER IS MEASURED IN 'WATTS'."
7610 LINE INPUT A$:PRINT C$;
7615 PRINT"  3.  POWER HAS A DIRECT"
7620 PRINT"RELATIONSHIP TO VOLTAGE AND"
7625 PRINT"CURRENT, BUT AN INVERSE"
7630 PRINT"RELATIONSHIP TO RESISTANCE."
7635 PRINT"  4.  THE FORMULAS USED IN DC"
7640 PRINT"POWER CALCULATIONS ARE P=IE,"
7645 PRINT"P=E SQUARED/R, AND P=I SQUARED"
7650 PRINT"P=I SQUARED X R."
7655 PRINT"IN ANY DC CIRCUIT THE POWER"
7660 PRINT"USED BY EACH INDIVIDUAL"
7665 PRINT"COMPONENT IS ADDITIVE."
7670 LINE INPUT A$:PRINT C$;
7675 PRINT"  6.  WATTAGE RATINGS OF RESISTORS"
7680 PRINT"DEPEND UPON THEIR SURFACE AREA."
7685 PRINT"  7.  A SAFETY FACTOR OF 2-4"
7690 PRINT"IS USED IN MOST ELECTRONIC EQUIP-"
7696 PRINT"MENT AS A SAFETY STANDARD."
7700 LINE INPUT A$:PRINT C$;
7705 PRINT"YOU ARE NOW READY FOR THE"
7710 PRINT"POST TEST.  PUSH THE RETURN"
7715 PRINT"KEY WHEN YOU WISH TO TAKE IT."
7720 LINE INPUT A$:PRINT C$;
7725 RUN"ELEC#17E,0
OK

LOAD"ELEC#17E
WORKING...
OK

LIST

1 REM N=CAI I.D. NUMBER
2 REM N$=STUDENT NAME (FIRST NAME)
3 REM S$=SOCIAL SECURITY NUMBER
4 C$=CHR$(27)+";"
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5 PRINT C$;
6 REM - THIS IS THE DC POWER POSTTEST.
7 REM - CODE ON DISK IS "ELEC#17E'
100 C$=CHR$(27)+";"
120 PRINT C$;
2160 PRINT"NOW THAT WE'VE DISCUSSED POWER,"
2165 PRINT"WORK, FORCE, ENERGY, AND WATT,"
2170 PRINT"LET'S CHECK TO SEE IF YOU HAVE"
2175 PRINT"MASTERED THE IDEAS I'VE TRIED"
2180 PRINT"TO TEACH YOU."
2185 LINE INPUT A$:PRINT C$;
2186 PRINT"THIS WILL BE THE START OF THE"
2187 PRINT"POST-TEST FOR THE LESSON.  DO"
2188 PRINT"THE BEST YOU CAN AS YOU WILL
2189 PRINT"BE GIVEN ONLY ONE CHANCE AND"
2190 PRINT"YOUR SCORE WILL BE RECORDED"
2191 PRINT"FOR POSTERITY.  GOOD LUCK."
2192 CN=0
2193 LINE INPUT A$:PRINT C$;
2195 PRINT"  1.  THE TIME RATE AT WHICH WORK IS"
2196 PRINT"DONE IN AN ELECTRICAL CIRCUIT"
2197 PRINT"IS MEASURED IN --------?
2200 PRINT"  POWER"
2205 PRINT"  ENERGY"
2210 PRINT"  WATTS
2211 PRINT
2212 PRINT"(TYPE IN CORRECT WORD)
2213 INPUT A$
2215 IF A$="WATTS" THEN 2220
2216 GOTO 2225
2220 CN=CN+1
2225 PRINT C$;
2300 PRINT"  2.  A WATT-HOUR METER READS THE"
2305 PRINT"PRODUCT OF --------?"
2310 PRINT"  1.  ENERGY AND TIME"
2315 PRINT"  2.  POWER AND CURRENT"
2320 PRINT"  3.  TIME AND POWER"
2325 PRINT"  4.  POWER AND ENERGY"
2330 PRINT
2335 PRINT"(TYPE IN NUMBER OF YOUR ANSWER)"
2340 INPUT A
2345 IF A=3 THEN 2355
2350 GOTO 2360
2355 CN=CN+1
2360 PRINT C$;
2400 PRINT"  3.  THE AMOUNT OF WORK DONE PER"
2410 PRINT"UNIT TIME DESCRIBES -------?"
2420 PRINT"  1.  CURRENT"
2430 PRINT"  2.  VOLTAGE"
2440 PRINT"  3.  RESISTANCE"
2445 PRINT"  4.  POWER"
2450 PRINT
```

```
2455 PRINT"(TYPE IN CORRECT NUMBER)"
2460 INPUT A
2465 IF A=4 THEN 2475
2470 GOTO 2480
2475 CN=CN+1
2480 PRINT C$;
2500 PRINT"  4.  ELECTRIC ENERGY USED IN THE"
2505 PRINT"HOME IS PAID FOR ACCORDING TO"
2510 PRINT"THE NUMBER OF HOURS TIMES -----?"
2515 PRINT"  1.  MICROWATTS"
2520 PRINT"  2.  MILLIWATTS"
2535 PRINT"  3.  WATTS"
2540 PRINT"  4.  KILOWATTS"
2545 PRINT
2550 INPUT A
2555 IF A=4 THEN 2565
2560 GOTO 2570
2565 CN=CN+1
2570 PRINT C$;
2600 PRINT"  5.  THE ENERGY CONSUMED BY A DEVICE"
2605 PRINT"MAY BE CALCULATED BY MULTI-"
2610 PRINT"PLYING THE POWER BY -------?"
2615 PRINT"  1.  COULOMBS"
2620 PRINT"  2.  CURRENT"
2625 PRINT"  3.  RESISTANCE"
2630 PRINT"  4.  TIME"
2635 PRINT
2640 PRINT"(TYPE CORRECT NUMBER OF ANSWER)"
2645 INPUT A
2650 IF A=4 THEN 2660
2655 GOTO 2665
2660 CN=CN+1
2665 PRINT C$;
2700 PRINT"  6.  THE ABILITY TO DO WORK IS"
2710 PRINT"CALLED ------?
2715 PRINT"  1.  ENERGY"
2720 PRINT"  2.  WORK"
2725 PRINT"  3.  POWER"
2730 PRINT"  4.  FORCE"
2735 PRINT
2740 INPUT A
2745 IF A=1 THEN 2755
2750 GOTO 2760
2755 CN=CN+1
2760 PRINT C$;
2800 PRINT"  7.  WHICH ONE OF THE FOLLOWING IS"
2810 PRINT"A BASIC UNIT OF ELECTRICAL"
2815 PRINT"POWER?"
2820 PRINT"  1.  VOLT"
2825 PRINT"  2.  BOULOMB"
2830 PRINT"  3.  AMPERE"
2835 PRINT"  4.  WATT
```

```
2840 PRINT
2846 IF A=4 THEN 2855
2850 GOTO 2860
2855 CN=CN+1
2860 PRINT C$;
2900 PRINT"  8.  CURRENT FLOWING THROUGH A"
2910 PRINT"RESISTOR ALWAYS PRODUCES AN"
2915 PRINT"ENERGY LOSS IN A FORM CALLED"
2920 PRINT"--------?"
2925 PRINT"  1.  COUNTER EMF"
2930 PRINT"  2.  HEAT"
2935 PRINT"  3.  EDDY CURRENTS"
2940 PRINT"  4.  HYSTERESIS"
2950 PRINT
2955 INPUT A
2960 IF A=2 THEN 2970
2965 GOTO 2975
2970 CN=CN+1
2975 PRINT C$;
3000 PRINT"  9.  ELECTRICAL POWER CAN BE"
3005 PRINT"EXPRESSED AS -------?"
3010 PRINT"  1.  FORCE PER UNIT AREA"
3015 PRINT"  2.  COULOMBS PER UNIT TIME"
3020 PRINT"  3.  WORK PER UNIT TIME"
3025 PRINT"  4.  JOULES PER COULOMB"
3030 PRINT
3035 PRINT"(TYPE IN CORRECT NUMBER)
3040 INPUT A
3045 IF A=3 THEN 3055
3050 GOTO 3060
3055 CN=CN+1
3060 PRINT C$;
3065 I=CN*100/9
3070 PRINT""N$", YOUR SCORE ON THE POST-TEST"
3075 PRINT"WAS "CN" OR "I"%."
3080 PRINT"TO RECORD THE SCORE OF YOUR"
3085 PRINT"POST=TEST, MARK IT ON THE PROGRESS"
3090 PRINT"CHART IN THE SPACE PROVIDED UNDER"
3095 PRINT"LESSON #17."
3100 LINE INPUT A$:PRINT C$;
3135 IF I<80 THEN 3145
3140 IF I>=80 THEN 3175
3145 PRINT"IF YOU MISSED MORE THAN TWO OF THE"
3150 PRINT"9 QUESTIONS, THEN MAYBE THE PROGRAM WASN'T"
3155 PRINT"AS GOOD AS IT COULD HAVE BEEN.  AT ANY
RATE,"
3160 PRINT"YOU HAVE HAD A CHANCE TO USE CAI."
3165 PRINT"WHEN YOU GET A CHANCE, TAKE IT AGAIN.  SEE
YA."
3170 END
3175 PRINT"GOOD SHOW OLD CHAP.  YOU HAVE DONE WELL."
3180 PRINT"I HOPE THIS EXPERIENCE HASN'T BEEN TOO"
```

```
3185 PRINT"TRYING FOR YOU.  AT LEAST YOU KNOW"
3190 PRINT"WHAT CAI IS REALLY LIKE NOW."
3192 PRINT"REMEMBER YOUR NEXT LESSON IS #18."
3195 END
OK
```

APPENDIX D

University of Northern Colorado
Department of Industrial Arts and Technology
Electronics Lab

COMPUTER ASSISTED INSTRUCTION EVALUATION FORM

1. Name:_________________ Student Number:____________

2. Age:_______ Sex: _____ Male ____ Female

3. Class: ___Freshman ___Sophomore ___Junior ___Senior
___Graduate

4. Major: ________________________

5. Grade Point Average: _______________________

6. GATB Scores: ___ ___ ___ ___ ___ ___ ___ ___

7. 16PF Scores: ___ ___ ___ ___ ___ ___ ___ ___
___ ___ ___ ___ ___ ___ ___ ___

8. Level of Course Work Sought: ___ 1 ___ 2 ___ 3

9. What course(s) in electronics are you registered in:
___ 180 ___ 281 ___ 480 ___ Independent Study

10. How many lessons did you take? _____

11. Have you ever used the computer terminal before this class? ____ Yes ____ No

12. Did you take most of the computer lessons before or after using some other media or source? ___ Before ___ After (films, lectures, 35mm slikes, etc.)

13. Were you apprehensive about operating the terminal?
___ Yes ___ No

14. Are you as apprehensive now about operating the terminal? ___ Yes ___ No

15. How much time did it take for you to complete the average lesson? ____ min. Pre-post test only: ____ min.

16. Tests and lessons. ____ 0-15 min. ____ 15-30 min.
____ 30-45 min. ____ 45-60 min. ____ 60-or more min.

17. Was the rate of display for the information on the screen (1200 BAUD) suitable for your needs? ___ Too slow
___ About right ___ Too fast

18. Were the diagram books used for the lessons adequate? _____ Yes _____ No -- Reason ______________________

19. Did the pre and post test questions seem to cover the materials in the computer? _____ Yes ______ No Explain ____

20. Was the difficulty of the questions within reason for the computer lessons? _____ Yes ____ No Explain ____

21. Were the terminals available to you when you wanted to take a lesson? ____ Yes ____ No Explain ______________

22. Did the computer lessons help you as much as the other media available such as textbooks, slides, film, video-tapes and lectures? ____ Yes ____ No Explain __________

23. Do you feel the computer lessons help you remember the material? ____ Better than other sources ____ About the same ____ Less than other sources

24. Did your eyes bother you or did you feel any physical fatigue as you took the computer lessons? ____ Yes Explain ________________________________ ____ No

25. Was the delay (15-20 seconds) for loading each section of the lesson into the computer a big problem for you in regards to holding your attention on the lesson? ___ Yes ____ No

26. Was the readability of and terminology in the lessons within a level that allowed you to understand what was being presented? ____ Yes ____ No Explain ______________

27. In your opinion, can the computer teach you to perform the skills required in the course, such as meter operation, measurement techniques, etc.? ____ Yes ____ No Explain ____

28. Do you feel the computer can help you get a better grade on the tests in the course? ____ Yes ____ No

29. Do you feel you can cover more material quicker with the computer lessons than with other media, such as films, slides, video-tapes, etc.? ____ Yes ____ No

30. Did you like to take lessons on the computer? ____ Yes ____ No

31. Did you like the self-pacing of the lessons or would you like to have the materials presented on a timed basis by the machine? ____ Controlled by me ____ Controlled by the computer

32. Do you prefer the teacher generated (traditional type test) or the computer generated exams? ____ Teacher made tests ____ Computer generated tests ____ No preference, either worked and seemed okay

33. As an instructional tool, would the computer test be more or less helpgul if you could find which question you missed as you take the tests? ____ More helpful to know ____ Less hekpful if known ____ No opinion

34. Was the complexity of terminal operation to "take a lesson" easy for you once you had experienced a lesson or two? ____ Yes ____ No Explain ____________________

35. Did you feel the computer was a "personalized" instruction system which made you comfortable as learning was taking place? ____ Yes ____ No Explain ____________________

36. Did you, at any time, feel "threatened" by the computer as you were taking a lesson or an exam? ____ Yes ____ No

APPENDIX E

ELECTRICITY/ELECTRONICS INTERVIEW SCHEDULE

Class ________ Quarter ________

1. Name ____________________________ FR SO JR SR GR

2. What is your purpose in registering for this class?
___ Major ___ Amateur Radio ___ G.E. Elective
___ I.A. Elective ___ Electronics Concentration
___ Other____

3. What do you expect from the class? _____________________
____

4. What is your general rating of you as a student?
____ Excellent ____ Good ____ Fair ____ Must Work Hard

5. a. Do you have any set pattern of study that you use in preparing for your classes? ___ Yes ___No
b. Do you feel satisfied with your existing pattern if you have one? ____ Yes ____ No
c. Recommendations____
____

6. What preference do you have for class operation? How do you feel most comfortable?
____ Prefer to have teacher tell me what to do in class and lab through lecture/demonstration
____ Like to work on my own after assignments have been made or overview lecture given by instructor
____ Like to determine my own goals and work on my own on predetermined objectives for the course

7. What kind of course evaluations would you prefer?
____ Computer generated test (individual over materials or packets covered)
____ Performance exam individually administered over materials covered
____ Both
Level of course work sought ___ Recall ___ Application
___ Analysis-synthesis Other___________________________

8. What special interests do you have in life--hobbies, leisure activities, free time interests or work associations?____
What emphasis might this have for the course? __________
____

9. What do you expect out of life and this program of higher education in which you are now actively engaged?_____
____

10. Recommended program of studies in this course are as follows: (Packets or activities to be covered this quarter) ____
____
____
____
____
____
____

APPENDIX F

UNIVERSITY OF NORTHERN COLORADO
Department of Industrial Arts and Technology

Course Outlines
D. L. Jelden

ELECTRICITY/ELECTRONICS INFORMATIONAL ANALYSIS

Instructional analysis of course content found in the computer lessons in the lab.

IAT 180 - General Electricity (3 quarter hours credit)

Unit I HISTORY AND ELECTRON THEORY

A. Historical development of electricity
B. Safety in the electrical shop
C. Atomic structure of matter
D. Law of electrical charges (E.M.F.)
E. Definition of electricity (static and dynamic)
F. Electron motion and current flow
G. Electrical terminology
H. Units of electrical measure and their symbols
I. Mathematical applications for electricity
J. Job opportunities in electricity-electronics
K. Safety around electric equipment
L. Morse Code

Unit II MAGNETISM

A. History and backgroung of magnetism
B. Types of magnets
C. Theory of magnetism
D. Magnetic properties of materials
E. Shapes of magnets
F. Theory of magnetic measurement
G. Laws and theories of electromagnetism
H. Applications of electromagnetism
I. Theory of magnetic induction
J. Theory of magnetic circuits
K. Theory of magnetic shielding

Unit III PRODUCTION OF ELECTRICITY

A. Sources and methods of producing electrical energy
B. Types of electrical current
C. Maintenance and limitation of electrical generators and alternators
D. Applications of electrical generators

Unit IV D.C. CIRCUITS

A. Types and sizes of electrical conductors
B. Purpose and types of electrical insulation
C. Theory of circuit layout
D. Ohm's Law for D.C. circuits
E. Applications of schematic diagram symbols
F. Kirchhoff's Laws for D.C. circuits
G. Watts' Law for D.C. circuits
H. Types, sizes and functions of fixed resistances
I. Types, sizes and functions of variable resistances
J. Purpose and function of E.I.A. resistor color code
K. Applications of voltage dividers
L. Definitions and applications of mathematical prefixes
M. Sizes and types of circuit protection devices
N. Types and sizes of electrical switches
O. Theory of varying or pulsating D.C.
P. Effects of electric current
Q. Theory and application of hooking cells in series and parallel
R. Types of electric energy (kinetic and potential)
S. Comparison of mechanical and electric power
T. Measurement of electric power
U. Function and application of power networks (power factor)
V. Functions of circuit diagrams
W. Theory and background of semi-conductors
X. Electrical drafting

Unit V SAFETY

A. Rules for working with eleectrical devices
B. Proper use of sockets, switches and extension cords
C. Proper grounding of electrical devices
D. Effects of ('I') current on human body
E. First aid for electric shock

Unit VI ALTERNATING CURRENT

A. Theory of A.C. generation
B. Characteristic and function of sine curve
C. Values of A.C. voltage and current
D. Meaning of phase and phase angle
E. Explanation of frequency spectrum

IAT 281 - Electro-Mechanical Equipment and measuring Instruments (2 quarter hours credit)

Unit VII INDUCTANCE AND INDUCTORS

A. Characteristics and effects of inductance
B. Measurement of inductance
C. Theory and application of inductive circuits
D. Theory and application of Lenz's Law
E. Theory of transformer operation
F. A.C. circuit calculations
G. Types, sizes and applications of coils and inductive devices
H. Factors controlling inductance

Unit VIII TRANSFORMERS

A. Characteristics, types and uses of transformers
B. Impedance matching in power transformers
C. Theory of transformer construction
D. Interpretation of transformer color code
E. Transformer power losses

Unit IX CAPACITANCE AND CAPACITORS

A. Definition and theory of capacitance
B. Types and physical construction of capacitors (fixed and variable)
C. Theory of capacitive measurements
D. Causes and effects of capacitance
E. Interpretation of E.I.A. capacitor color code
F. Circuit application of capacitors

Unit X A.C. CIRCUIT ANALYSIS

A. Theory of I.R.C. series circuits
B. Theory of E.R.C. parallel circuits
C. Vector addition of currents
D. Calculations of circuit impedance (z)
E. Effect of frequency on A.C. circuits
F. Characteristics and applications of series paralles resonant circuits
G. Functions of filter circuits
H. Applications and types of filter circuits
I. Frequency measurement and waveform characteristics of R.F.
J. Methods of coupling A.C. circuits
K. Circuit network theorems

Unit XI MOTORS AND GENERATORS

A. Theory, operation, types and construction of D.C. generators
B. Theory, operation, types and construction of D.C. motors
C. Purpose and need for D.C. motot control
D. Requirements of motor and generator maintenance
E. Theory, operation, types and construction of alternators
F. Need for frequency and voltage regulation in alternators
G. Theory, operation, types and construction of A.C. motors
H. Requirements of A.C.-D.C. motor protection and control
I. Methods of rewinding motors and generators
J. Motor efficiency
K. Servo control systems

Unit XII ELECTRIC WIRING AND ILLUMINATION

A. Purpose and function of national board of fire underwriters
B. Need and purpose of national electric code
C. Selection and requirements of service entrance
D. Types and applications of switches and controls for housewiring
E. Theory of light production by current passing through low pressure gas
F. Types and operation of gas discharge lamps
G. Operation and application of arc lights
H. Electric power and poly-phase systems
I. Need, application, and calculation of branch circuits
J. Adequate wiring requirements
K. Theory and need for good lighting
L. Selection and installation of material for housewiring

Unit XIII MEASURING INSTRUMENTS

A. Theory, types and application of meter movements
B. Purpose and methods of meter calibration
C. Interpretation of meter scales and ranges
D. Characteristics of commercial meters
E. Care and applications of measuring instruments
F. Crystal rectifiers and rectification principles

Unit XIII (Continued - Measuring Instruments)

G. Oscilloscope operation and theory
H. Theory, operation and calibration of frequency generators

IAT 480 - Electronic Circuit Applications (5 quarter hours credit)

Unit XIV INTRODUCTION TO ELECTRONICS

A. Historical development of electronics
B. General applications of electronics
C. Basic transmitter and receiver operation
D. Types and purpose of electronic symbols
E. New electronic developments
F. Assembly techniques for electronic components
G. Job opportunities in electronics
H. Types and operation of electronic components
I. Theory and operation of telephony

Unit XV ELECTRON TUBES

A. Physical characteristics and construction of electron tubes and sockets
B. Theory of tube and pin numbering systems
C. Operating theory of vacuum tubes
F. Types and classification of vacuum tubes
G. Purpose and types of bias supplies
H. Theory of triode amplification
I. Vacuum tube terminology
J. Purpose and operating theory of vacuum tube grids
K. Typical operating conditions of vacuum tubes
L. Special characteristics of vacuum tubes
M. Tube parameter and dynamic characteristics of vacuum tubes

Unit XVI SEMI-CONDUCTORS

A. Effect, purpose and development and miniturization of electronic components
B. Theory and operation of semiconductors
C. Physical properties of semiconductors
D. Types, sizes and construction of semiconductors
E. Theory of characteristic curve of semiconductors
F. Semiconductor testing techniques

Unit XVI (Continued - Semi-Conductors)

G. Future development and applications semiconductor materials
H. Techniques in handling semiconductors
I. Transistor specifications and number systems
J. Industrial applications of transistors
K. Effectiveness of integrated circuits in the economics of the electronics industry
L. Development of transistors as active electronic devices
M. Theory and application of monolithic integrated circuits
N. Characteristics of thin film circuits
O. Structure of hybrid integrated circuits
P. Operation and application of digital integrated circuits
Q. Operation and application of linear integrated circuits
R. Theory of integrated circuit design
S. Power disipation and temperature effects of integrated circuits
T. Manufacturing and processing of integrated circuits
U. Types, sizes and specifics of integrated circuits
V. Reliability and failure analysis of integrated circuits
W. Future capabilities of integrated circuits

Unit XVII POWER SUPPLIES

A. Power supply requirements for circuits and components
B. Types, function, and development of radio batteries
C. Theory and applications of transistorized power supplies
D. Theory, types and application of rectifiers
E. Theory, types and application of filter circuits
F. Purpose, function and operation of voltage doubler and tripler circuits
G. Theory and operation of vibrator power supplies

Unit XVIII AMPLIFIERS

A. Physical nature of sound
B. Development of harmonics and their effects in electronics
C. Electrical transmission and reproduction of sound

Unit XVIII (Continued - Amplifiers)

D. Requirements and developments of high-fidelity and stereophonic sound systems
E. Types, application and classification of amplifiers
F. Theory and operation of various types of amplifier circuits
G. Types and operation of common amplifier coupling circuits
H. Rating and measurement of amplifier outpur
I. Need for temperature stabilization in transistor amplifiers
J. Comparison of vacuum tube and transistor amplifiers
K. Methods of biasing transistors
L. Operation and purpose of amplifier controls and control circuits
M. Types and theory of feedback in amplifiers
N. Purpose and need for decoupling circuits
O. Methods and need for circuit shielding
P. Theory and operation of volume control circuits
Q. Theory, operation and application of magnetic amplifiers
R. Design of transistor amplifiers

Unit XIV OSCILLATORS

A. Purpose, function and operation of electronic oscillator
B. Methods of feeding oscillator circuits
C. Types and theory of L-C oscillators
D. Types and theory of R_C oscillators
E. Purpose and operation of frequency controls
F. Types and application of commercial signal or frequency generators

Unit XV TRANSMITTERS

A. Types, theory and operation of A-M transmitters
B. Types, theory and operation of F-M transmitters
C. Methods of modulating of keying A-M transmitters
D. Methods of modulating of keying F-M transmitters
E. Methods of coupling transmitter circuits
F. Purpose of and need for carrier frequency stabilization
G. Nature, characteristics, and theory of radio waves

Unit XV (Continued - Transmitters)

H. Theory of electromagnetic wave propagation
I. Types, characteristics and theory oftransmission lines and antennas
J. Purpose and operation of sideband transmission
K. Principles of T-V transmission
L. Theory and types of microphones and transducers

Unit XX RECEIVERS

A. Types, characteristics and theory of A-M radio receivers
B. Types, characteristics and theory of F-M radio receivers
C. Methods and limitations of demodulation in A-M receivers
D. Methods and limitations of demodulation in F-M receivers
E. Theory and procedure of A-M receiver alignment
F. Theory and procedure of F-M receiver alignment
G. Methods and procedure of radio repair and troubleshooting
H. Theory and types of time delay circuits
I. Theory of logic circuitry
J. Principles of gating and counting circuits
I. Theory of logic circuitry
J. Principles of gating and counting circuits
K. Theory of T-V receivers

Unit XXII CIRCUIT APPLICATIONS (MISCELLANEOUS CIRCUITS)

A. Theory and types of microphone pickups
B. Theory and types of transducers
C. Theory and applications of time delay circuits
D. Theory of gating and counting
E. Theory and application of thermister
F. Principles and application of logic circuitry
G. Principles of television receivers (black and white and color)
H. Photo-electric controls
I. Induction heating
J. Ultra-sonic cleaning
K. Thermo-electric cooling
L. Ampliphase AM transmitter
M. SS-transmitter-receiver
N. Servicing transistor circuits
O. Multiplexing-complex modulation

Unit XXII (Continued - Circuit Applications)

P. Modulating-waveshaping
Q. Klystrons
R. Magnetrons
S. Thyratrons
T. Radar and sonar
U. Telemetry
V. Amature radio rules and regulations
W. Digital computers
X. Laser and maser
Y. Holography
Z. Transistorized ignition systems
AA. Operational Amplifiers
AB. Phase lock loops
AC. Analog Computers

IAT 485 - Digital/Microprocessors (3 quarter hours credit)

Unit XXIII MICROPROCESSOR BASICS

A. Characteristics of basic digital logic circuits (AND, OR, NOT, NAND, NOR, AND EXCLUSIVE, OR EXCLUSIVE)
B. Applications of logic probes in troubleshooting
C. Operation and application of flip-flop circuits (R-S, J-K, D)
D. Theory and operation of Asynchronous and Synchronous F-F counters
E. Programming F-F counters for up, down and stop counts
F. Theory and application of common digital display devices (LED and LCD with 7-segment readout)
G. Characteristics of digital IC families and their operational limits
H. Theory and application of machine language in digital (binary, octal hexadecimal)
I. Types and characteristics of common micro-processor families (TTL & CMOS in 4-BIT, 8-BIT, 16 BIT word sizes)
J. Requirements for interfacing micro-processors
K. Types of micro-processor memories (RAM, ROM, PROM, EPROM, EAPROM, STATIC, DYNAMIC)
L. ALU circuitry operation
M. Input/output requirements for registers, memory and micro-porcessor devices
N. Serial/paralles input-output systems found in digital/micro-processor circuits
O. Basic design and characteristics of micro-processor families

Unit XXIII (Continued - Microprocessor basics)

P. A to D and D to A converter requirements to interface micro-processors

Q. Programming and coding systems found in micro-processors (op-codes interpreter and compiler languages available)

R. Applications of micro-processors in consumer products

S. Operation and programming micro-computers for common applications

ELECTRICITY/ELECTRONICS MANIPULATIVE OPERATIONS

Unit I MEASUREMENT OF:

A. D.C. voltage
B. Resistance
C. Vacuum tube pin voltages
D. A.C. voltage (rms.)
E. D.C. current
F. Capacitance
G. Signal voltage
H. Frequency
I. A.C. current
J. Peak to peak voltage
K. Wattage
L. Pulse voltage
M. Signal degeloped bias
N. Impedance
O. Internal resistance
P. Tuned circuit frequency
Q. Gain in decibels
R. Inductance
S. Power consumption
T. Feedback control voltage
U. Repetitive pulse rate
V. Modulation voltage
W. Transformer's turns ratio
X. Current dissipation of tube elements

Unit II ALIGNMENTS OR ADJUSTMENTS OF:

A. Oscillator circuit
B. I.F. amplifier in A.M.
C. Drive voltage
D. R.F. amplifier
E. Discriminator circuit
F. I.F. amplifier in F.M.
G. Frequency trap
H. Balance of push-pull amplifier
I. Video I.F.
J. Band pass filter
K. R.F. band pass
L. Automatic frequency control (A.F.C.)
M. Ratio detector circuit
N. Band limits

Unit III CALIBRATION OF:

A. Voltage in volts
B. Frequency
C. Dial setting
D. Band limits
E. Component in frequency

Unit IV ANALYSIS OF COMPONENT FOR:

A. Transistor output
B. Frequency stability
C. High frequency response
D. Square wave reproduction
E. Sensitivity
F. Noise level
G. Amplifier distortion
H. Audio amplifier gain
I. Signal losses
J. Audio frequency response
K. Amplifier linearity
L. Thermal stability
M. High frequency gain
N. Q in resonant circuits
O. Selectivity
P. Flatness of input of output response
Q. Input or output impedance
R. High or low pass filter effectiveness
S. Tuner circuit tracking

Unit V ANALYSIS OF CIRCUIT OPERATION FOR:

A. Continuity
B. Shorted circuits
C. Open circuits
D. Resistance relationships (no power)
E. Proper power supply voltage
F. Filament voltage
G. Circuit output
H. Powerline input voltage
I. Intermittents
J. Signal voltage by tracing
K. Drive voltage
L. Defects in signal source
M. Signal intensity
N. Instability of oscillator
O. Detector output
P. Effect of decoupling capacitor
Q. Sweep voltage
R. Sync. function
S. Oscillator injection voltage
T. Synchronizing separator action
U. Automatic frequency control

Unit VI **ANALYSIS OF WAVE FORM FOR:**

A. A.C. component in D.C. source
B. Ripple frequency
C. Voltage component
D. Phase shift
E. Harmonics
F. Parasitic oscillation

Unit VII **CHECKS OR TESTS FOR:**

A. Loose connections
B. Open resistor
C. Shorted Capacitor
D. Capacitor leakage
E. Open capacitor
F. Open filament
G. Open winding
H. Shorted tube
I. Open tube
J. Shorted winding
K. Gassy tube
L. Tube emission
M. Tube leakage
N. Tube transconductance
O. Electrolytic power factor

APPENDIX G

UNIVERSITY OF NORTHERN COLORADO
Department of Industrial Arts and Technology

ELECTRICITY/ELECTRONICS

Sample of Pre-post evaluation of electronics taught in basic class. The IAT 281, 480, and 485 had similar types of exams.

The code under each item identifies the question for unit, topic, and level in the CAI test file. Item number one is for unit number one, topic B level number one. These 100 questions were selected by the computer at random from a total of 9252 question found in the data file.

IAT 180 - Pre-Test

DIRECTIONS: Look the test over quidkly to see that it is complete. Below are a series of true-false and multiple-choice questions designed to evaluate your understanding of some basic facts about electricity/electronics. Read each statement and mark the correct answer by blocking out the proper space on the answer sheet which accompanies this test. Be sure each item is completed, as an omitted response will be counted wrong. Also, check to see that your name, class and section number and test title are recorded in the proper place on the answer sheet. There is no time limit for the test and any type of soft pencil or pen can be used as the test will be hand scored. When completed. submit your answer sheet to the instructor for scoring and then evaluate your mistakes, if any.

1. A fuse should be placed in series with the circuit to protect it.
    1. true
1 Bl   2. false

2. The particles of electricity revolving around the nucleus of the atom are called:
    1. protons
1 Cl   2. neutrons
    3. photons
    4. electrons

3. One of the following is not an atomic particle:
    1. proton
1 Cl   2. electron
    3. neutron
    4. phanotron

4. Water is scientifically classified as a/an:
    1. compount
1 Cl   2. element
    3. mixture
    4. molecule

5. If an atom loses one of its negative charges, the atom:
    1. is negatively charged
1 Dl   2. is positively charged
    3. is neutral
    4. becomes stable

6. The basic positive electric charge is known as:
    1. neutron
1 Dl   2. nucleus
    3. proton
    4. electron

7. A neutral atom has a net positive charge.
    1. true
1 Dl   2. false

8. Free electrons are normally liberated from:
    1. inner orbits of atoms of gaseous elements
1 El   2. the nucleus of all atoms
    3. outer orbits of atoms of metallic elements
    4. the protons of metallic elements

9. Lightning is an example of:
    1. contact discharge of static electricity
1 El   2. induction charge of static electricity
    3. arc discharge of static electricity
    4. friction charge of static electricity

10. According to the accepted concept, electric current is:
    1. the electron at rest
1 Fl   2. an organized flow of electrons
    3. the movement of atoms
    4. the movement of protons

11. Electrons travel in a path from:
    1. + to -
1 Fl   2. - to +
    3. high to low altitude
    4. low potential to high potential

12. Devices of materials which readily permit the flow of electric current are called:
    1. capacitors
1 Fl   2. conductors
    3. inductors
    4. insulators
    5. resistors

13. When the electrons of a substance are tightly bound, it will not readily permit the flow of electric current. Such a substance is called:
    1. a conductor
    2. an electrolyte 1 Fl
    3. an insulator
    4. a magnetostriction
    5. a thermocouple

14. Current will flow between two points in a circuit when:
    1. the difference of potential between the two points is zero
    2. a difference of potential exists between the two points 1 Gl
    3. the circuit is opened
    4. only chemical or mechanical actions are present

15. The magnetic field around a current-carrying conductor:
    1. forms concentric circles
    2. is parallel to the conductor 1 Gl
    3. remains after the current flow ceases
    4. decreases in strength as the current flow increases

16. A difference in potential is measured in:
    1. amperes
    2. volts 1 Gl
    3. milliamperes
    4. flux lines per square inch

17. Electromotive force is measured in:
    1. ohms
    2. power 1 Hl
    3. volts
    4. resistance between battery terminals

18. The unit of resistance is the :
    1. ohm
    2. volt 1 Hl
    3. ampere
    4. watt

19. The instrument normally used to measure electric current is called a/an:
    1. voltmeter
    2. ohmmeter 1 Hl
    3. frequency meter
    4. ammeter
    5. galvanometer

20. In-service programs are not conducted by most industries because of the insufficient need for updating electronics knowledge.
1. true
1 J1 2. false

21. Lodestone and magnetite are examples of artificial magnets.
1. true
2 B1 2. false

22. When two like magnetic poles are placed close together:
1. the force between them increases as the poles are separated
2 C1 2. a force of attraction exists
3. a force of repulsion exists
4. the magnetic field decreases to zero

23. The ability of a magnetic substance to holds its magnetism after the magnetizing force has been removed is:
1. residual
2 C1 2. retentivity
3. hysteresis
4. permeability

24. Magnetic lines of force leave the magnetic north pole and enter the magnetic south pole.
1. true
2 C1 2. false

25. Most permanent magnets and all electro-magnets are:
1. classed as natural magnets
2 C1 2. manufactured in various shapes from lodestone
3. classed as artificial magnets
4. manufactured in various shapes from amagnetite

26. Maximum induced voltage occurs when the conductor:
1. moves parallel to the magnetic lines of force
2 C1 2. is stationary in the magnetic field
3. moves perpendicular to the magnetic lines of force
4. rotates clockwise

27. Glass makes a good insulator for magnetic lines.
1. true
2 D1 2. false

28. A non-magnetic material is:
1. iron
2 D1 2. cobalt
3. nickel
4. copper

29. Which of the following has the greatest reluctance?
1. ferrites
2 D1 2. steel
3. air
4. iron

30. If two bar magnets are suspended near each other in such a fashion that they are free to rotate:
1. the dielectric fields will cancel
2 E1 2. the electromagnetic fields will cancel
3. the north pole of one will attract the north pole of the other
4. the north pole of one will attract the south pole of the other
5. the south pole of one will attract the south pole of the other

31. The ability of a material to be easily magnetized is referred to as its:
1. retentivity
2 F1 2. reluctance
3. permeability
4. flux

32. The unit of electrical magneto-motive force is the:
1. gilbert
2 F1 2. joule
3. henry
4. coulomb
5. farad

33. Soft iron cores are often used in electromagnets because:
1. they produce stronger magnetic fields
2 G1 2. hard iron is too expensive
3. they provide support for the loops of wire
4. they have high reluctance values

34. Increasing the current in a wire:
1. increases flux line density
2 G1 2. decreases flux line density
3. has no effect on flux line density
4. creates two magnetic fields

35. Moving a conductor through a magnetic field produces voltage by:
1. induction
2 G1 2. mechanical pressure
3. light
4. heat
5. chemical activity

36. The magnetic field surrounding a wire expands and contracts with a varying current.
1. true
2 Gl 2. false

37. A magnetic circuit breaker:
1. protects a circuit against overloads
2 Hl 2. keeps a circuit open under normal conditions
3. must be replaced once it operates
4. trips when the circuit current falls below a certain value

38. Relays may be classified as:
1. normally energized, normally closed
2 Hl 2. normally closed, normally de-energized
3. normally closed, normally open
4. normally energized, normally open

39. A scredriver that is magnetized may be demagnetized by subjecting it to a strong:
1. decreasing AC magnetic field
2 Hl 2. DC magnetic field
3. electromagnetic field
4. electrostatic field
5. permanent magnetic field

40. The best material to provide shielding against stationary magnetic fields is:
1. soft iron
2 Kl 2. aluminum
3. copper
4. brass

41. Thermoelectric generators produce energy by means of:
1. heat
3 Al 2. light
3. pressure
4. chemical reaction

42. The voltage of a dry cell usually depends upon:
1. its size
3 Al 2. its shape
3. the type of materials used in the cell
4. the thickness of the plates

43. Of the six methods of producing a voltage, which is the least used?
1. chemical action
3 Al 2. heat
3. friction
4. pressure

44. The electric potential of a battery is developed by:

3 Al

1. chemical action
2. friction
3. light
4. magnetism

45. Batteries are classified as:

3 Al

1. primary cells only
2. secondary cells only
3. primary and secondary cells
4. primary and tertiary cells

46. The following must be an alternating current:

3 Bl

1. it rises from 0 to 10 amperes
2. it constantly stays at 5 amperes
3. it periodically changes its direction
4. it splits up into two currents when it reaches two branches of a circuit

47. Insulation on 100 volt AC line should be ---?--- when compared to that used on 100 volt DC line.

3 Bl

1. thicker
2. thinner
3. the same

48. The usable energy output of an energy converter is normally:

3 Bl

1. constant regardless of the amount of the energy input
2. more than the energy input
3. the same as the energy input
4. less than the energy input

49. An electric current which does not vary in either amplitude or direction is called:

3 Bl

1. alternating current
2. damped current
3. direct current
4. pulsating direct current
5. none of the above

50. In static electricity like charges:

3 Bl

1. attract
2. are neutral
3. repel
4. cancel

51. Materials having a large supply of free electrons are called:

4 Al

1. insulators
2. resistors
3. nonconductors
4. conductors

52. An increase in temperature affects the resistance of a conductor.
    1. true
4 A1 2. false

53. The current carrying capacity of a wire (other things being equal):
    1. doubles as the cross sectional area of the wire size doubles
4 A1 2. remains the same as the cross sectional area of the wire size doubles
    3. increases in relation to the (E) voltage applied
    4. increases by the square of the change in wire size (diameter)

54. To be a good insulator, a material should:
    1. have many free electrons
4 B1 2. be a semiconductor
    3. be affected very little by temperature
    4. be a metal

55. Current travels through insulators with difficulty because:
    1. free electrons are too few
4 B1 2. their resistance is too low
    3. their atoms have too many protons
    4. their construction is incorrect

56. The term "dielectric strength" means most nearly the ability of a/an:
    1. conductor to handle high voltages
4 B1 2. insulator to withstand electric stress across it without breaking down
    3. conductor to store large values of voltage
    4. insulator to pass high current without breaking down

57. All substances, being matter, offer the same amount of resistance to the flow or pressure of electricity.
    1. true
4 B1 2. false

58. The most accurate statement is that current flow requires:
    1. a switch in the circuit
4 C1 2. a variable resistor in the circuit
    3. a very high voltage in the circuit
    4. a voltage source

59. Using four resistors in a circuit, which combination would offer the least total resistance to the power source?
1. all four in series
4 C1 2. all four in parallel

60. When two AC voltages are in phase:
1. they have identical peak-peak values
4 D1 2. one reaches its peak value when is at zero
3. the period of one is exactly twice that of the other
4. they also have the same frequency

61. According to Ohm's Law, current in a circuit:
1. is directly proportional to the applied voltage
4 D1 2. is inversely proportional to the applied voltage
3. is directly proportional to the circuit resistance
4. is not affected by the applied voltage

62. The total resistance of a series circuit is equal to the:
1. smallest resistance in the circuit
4 D1 2. sum of all the individual resistances
3. largest resistance in the circuit
4. difference between the largest and smallest resistance

63. Ohm's Law can be expressed as:
1. I equals R/E
4 D1 2. I equals E/R
3. I equals R x E
4. I equals E x R

64. If three equal-value resistors are connected in series, the total circuit current is equal to:
1. the current in any one of the resistors
4 D1 2. three times the current in any one of the resistors
3. twice the current in any one of the resistors
4. one-third the current in any one of the resistors

65. One of Kirchhoff's laws states that:
1. the sum of the voltage drops around a circuit equals the voltage of the source
4 F1 2. the current around a closed circuit is zero
3. twice the current in any one of the resistors
4. the sum of the voltage drops across the various parts of a DC circuit exceeds the source voltage

66. The sum of the voltage drops in a series circuit is 70 volts. Therefore, the source voltage:
    1. may be less than 70 volts
4 Fl
    2. may be more than 70 volts
    3. cannot be more than 35 volts
    4. must be exactly 70 volts

67. In any circuit the total amount of current leaving a given point must be exactly equal to the total amount approaching that point.
    1. true
4 Fl
    2. false

68. A current flowing through the total resistance of a circuit produces a voltage drop:
    1. equal to and with the same polarity as the source voltage
4 Fl
    2. less than the source voltage, but of the same polarity
    3. greater than the source voltage and of the same polarity
    4. equal to but of opposite polarity to the source voltage

69. The word "watt" is an electrical term that:
    1. refers to the temperature of a conductor
4 Gl
    2. is the unit of electrical power
    3. distinguishes a conductor from an insulator
    4. indicates unknown qualities in the circuit

70. Maximum power transfer from the source to the load occurs when the oad resistance is:
    1. zero
4 Gl
    2. one-half the source resistance
    3. equal to the source resistance
    4. twice the source resistance
    5. infinity

71. Total power in a parallel circuit is equal to:
    1. sum of power in each branch
4 Gl
    2. the value of any branch
    3. sum of the reciprocal of all branches

72. When a resistor is replaced in a circuit, it is not sufficient to match the resistance value, but one must also check the:
    1. color code
4 Hl
    2. current rating
    3. energy rating
    4. power rating
    5. voltage rating

73. Wirewound resistors can be constructed ---?--- precisely than carbon resistors.
1. more
4 H1 2. less

74. Wirewound resistors are not generally rated as high in ---?--- as carbon resistors.
1. production cost
4 H1 2. precision resistance
3. ohmic value

75. Composition resistors are ---?--- to make than are wirewound resistors.
1. more expensive
4 H1 2. cheaper

76. A potentiometer is:
1. a device for measuring current
4 I1 2. a voltage divider
3. a type of fixed resistor
4. a device for measuring resistance

77. A variable resistor with two connections is called a:
1. carbon resistor
4 I1 2. rheostat
3. potentiometer
4. voltage divider
5. wirewound resistor

78. The color code for a 4.7 ohm resistor would be:
1. yellow, violet, black
4 J1 2. yellow, violet, silver
3. yellow, violet, gold
4. orange, violet, silver
5. orange, violet, gold

79. The color red indicates a number value of:
1. 2
4 J1 2. 3
3. 4
4. 7

80. The color code on a resistor will tell its power rating.
1. true
4 J1 2. false

81. The prefix "micro" means millionth.
1. true
4 L1 2. false

82. A millihenry equals:
1. one thousand henrys
4 L1 2. one million henrys
3. one millionth henry
4. one thousandth henry

83. When converted to megohms, 1,240,000 ohms is:
1. .124 megohm
4 Li 2. 12.4 megohms
3. 1.24 megohms
4. .00124 megohm

84. 100 pf equals how many microfarads?
1. .001
4 L1 2. .0001
3. .00001
4. .000001

85. The value of a 1/1,000 is expressed by the term:
1. mega
4 L1 2. micro
3. kilo
4. milli

86. The device used in circuits to prevent damage from overloading is called a:
1. fuse
4 M1 2. switch
3. resistor
4. connector

87. The voltage measured across a blown fuse will be:
1. zero
4 M1 2. the line voltage
3. the voltage rating of the fuse
4. ½ the line voltage

88. The meter used to indicate actual power used by a circuit is a/an:
1. ammeter
4 T1 2. voltmeter
3. wattmeter
4. wavemeter

89. Power factor is expressed in:
1. watts
4 U1 2. henrys
3. volt-amperes
4. percent

90. A bridge circuit can be used to measure capacitance and inductance.
1. true
4 V1 2. false

91. An acceptor substance may be one that:
1. displays negativity
4 W1 2. retains only positive charges
3. accepts electrons
4. positive charges are accepted

92. If electrical or electronic equipment is to be repaired, the following must be done before actual work is started
1. remove fuses from main switch
5 A1 2. short out main supply switch
3. have fire extinguisher handy
4. open and tag main switch

93. The control on the VTVM which determines the maximum amount of voltage to be measured is called the:
1. range switch
21 B1 2. function switch
3. zero adjust
4. Ohms adjust

94. Polarity of meter leads is important ---?---.
1. checking resistance of a coil
21 E1 2. when using a DC meter movement
3. when measuring AC voltage drop
4. when measuring resistance of parallel branches

95. Ammeters should always be connected in ---?--- with the circuit for proper operation.
1. series
21 E1 2. parallel
3. series-parallel
4. loosely

96. The higher the internal resistance of a volt meter, the ---?--- its accuracy.
1. lower
21 E1 2. higher

97. If the needle of the meter does not go to zero on the scale, the control which must be adjusted is the:
1. range switch
21 B1 2. function switch
3. zero switch
4. Ohms adjust

98. When the VOM is set on ohms and the leads are shorted together, if the needle does not deflect full scale, the control which must be adjusted is the:
1. range switch
21 B1 2. function switch
3. zero adjust
4. ohms adjust

99. To prevent possible damage to the ohmmeter section of the multimeter when measuring resistance in a circuit, the repairmen must first:

1. observe polarity when connecting test leads across the resistor
2. zero adjust the meter on all positions of the RANGE switch
3. turn off or disconnect the power to the circuit
4. set the RANGE switch to the highest position (R x 10000).

21 E1

100. Continuity checks with an ohmmeter are made with the instrument set to its ---?--- range.

1. highest
2. middle
3. lowest
4. what does continuity mean?

21 E1

APPENDIX H

MICROCOMPUTER SUPPLIERS FOR POSSIBLE EDUCATIONAL APPLICATIONS

COMPANIES LISTED BY PRODUCT/SYSTEM

MICROPROCESSOR SYSTEMS

International Business Machines Corporation
Old Orchard Road
Armonk, NY
10504 PH (914) 765-1900

NCR Corporation
Dayton, OH
45479 PH (513) 449-2000

Control Data Corporation
8100 34th Ave. South
Bloomington, MN
55440 PH (612) 853-8100

Digital Equipment Corporation
146 Main Street
Maynard, MA
01754 PH (617) 897-5111

Hewlett-Packard Company
1501 Page Mill Road
Palo Alto, CA
94304 PH (415) 857-1501

Data GeneralCorporation
4400 Computer Drive
Westboro, MA
01580 PH (617) 366-8911

Xerox Corporation
800 Long Ridge Drive
Stamford, CT
06904 PH (203) 329-8711

Texas Instruments incorporated
P. O. Box 225474
Dallas, TX 75265 PH (214) 995-2011

Wang Laboratories Inc.
One Industrial Avenue
Lowell, MA
01851 PH (617) 459-5000

Datapoint Corporation
9725 Datapoint Drive
San Antonio, TX
78284 PH (512) 699-7000

Itel Corporation
One Embarcadero Center
San Francisco, CA
94111 PH (415) 955-0000

Pertec Computer Corporation
12910 Culver Blvd.
Los Angeles, CA
90066 PH (213) 822-9222

Tandy Corporation
1800 One Tandy Center
Fort Worth, TX
76102 PH (817) 390-3700

California Computer Products, Inc.
2411 W. La Palma Avenue
Anaheim, CA
92803 PH (714) 821-2011

Apple Computer Incorporated
10260 Bandley Drive
Cupertino, CA
95014 PH (408) 996-1010

Commodore Business Machines Inc.
3330 Scott Blvd.
Santa Clara, CA
95051 PH (408) 727-1130

Applied Digital Data Systems, Inc.
100 Marcus Blvd.
Hauppauge, NY
11787 PH (516) 231-5400

Atari, Inc.
1265 Borregas Avenue
Sunnyvale, CA
94086 PH (408) 745-2200

California Computer Systems
250 Caribbean Drive
Sunnyvale, CA
94086 PH (408) 734-5811

Heath/Schlumberger
Hilltop Road
St. Joseph, MI
49085 PH (616) 982-3205

North Star Computers, Inc.
1440 Fourth Street
Berkeley, CA
94710 PH (415) 527-6950

SD Systems
3017 Lincoln
Garland, TX
75041 PH (214) 271-4671

Cromemco, Inc.
280 Bernardo Avenue
Mountain View, CA
94040 PH (415) 964-7000

Altos Computer Systems
2360 Bering Drive
San Jose, CA
95131 PH (408) 946-6700

MEMORY DEVICES (DRIVES, DISKS, ETC.)

Ampex Corporation
401 Broadway
Redwood City, CA
94063 PH (415) 367-2011

Prime Computer, Inc.
40 Walnut Street
Wellesley Hills, MA
02181 PH (617) 879-2011

BASF Systems
Crosby Drive
Bedford, MA
01730 PH (617) 271-4000

Verbatim Corporation
323 Soquel Way
Sunnyvale, CA
94086 PH (408) 245-4400

Dysan Corporation
5440 Patrick Henry Drive
Santa Clara, CA
95050 PH (408) 988-3472

Corvus Systems, Inc.
900 S. Winchester Blvd.
San Jose, CA
95128 PH (408) 246-0461

Wabash Tape Corporation
2700 Des Plaines Road
Des Plaines, IL
60018 PH (312) 298-8585

Shugart Associates
475 Oakmead Parkway
Sunnyvale, CA
94086 PH (408) 733-0100

Maxell Corporation of America
Data Products Group
60 Oxford Drive
Moonachie, NJ
07074 PH (201) 440-8020

Morrow Designs
5221 Central Avenue
Richmond, CA
94804 PH (415) 524-2101

TERMINALS AND PRINTERS

Mohawk Data Sciences
1599 Littleton Road
Parsippany, NJ
07057 PH (201) 540-9080

Tektronix, Inc.
P. O. Box 500
Beaverton, OR
97077 PH (503) 644-0161

Dataproducts Corporation
6200 Canoga Avenue
Woodland Hills, CA
91365 PH (213) 887-8000

Teletype Corporation
5555 Tougy Avenue
Skokie, IL
60077 PH (312) 982-2000

Centronics Data Computer Corporation
One Wall Street
Hudson, NH
03051 PH (603) 883-0111

Hazeltine Corporation
Comack, NY
11725 PH (516) 462-5100

Lear Siegler, Inc.
3171 South Bundy Drive
Santa Monica, CA
90406 PH (213) 391-7211

COMPUTER SOFTWARE PROGRAMS FOR SYSTEM MANAGEMENT AND CAI PROGRAM DEVELOPMENT

Microsoft
10800 NE Eighth, Suite 819
Bellevue, WA
98004 PH (206) 455-8080

International Software Service
13050 West Cedar Drive, #15
Lakewood, CO
80228 PH (303) 986-7664

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